

THE No 1 UK MAGAZINE FOR ELECTRONICS TECHNOLOGY & COMPUTER PROJECTS

# **EPE** EVERYDAY PRACTICAL ELECTRONICS

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## STARSHIP ENTERPRISE DOOR SOUNDER

Recreate the distinctive 'sssshhhh-thump' sound for your doors

## EPE MONOPOLY

**MONEY** Electronic banking  
for the popular board game

- ★ No more fiddling with paper money
- ★ Up to four Player 'stations' plus Banker 'station'



## UNIVERSAL HIGH-ENERGY LED LIGHTING SYSTEM – 1

Incredibly versatile rechargeable lighting

## **Plus** MINI THEREMIN – 2

Construction and setting up

\$7.95 US \$9.95 CAN  
JUNE 2008 PRINTED IN THE UK



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PROJECTS ... THEORY ...  
NEWS ... COMMENT ...  
POPULAR FEATURES ...

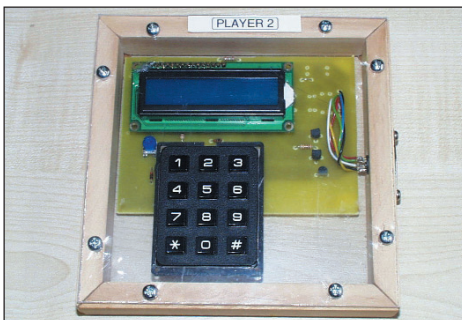
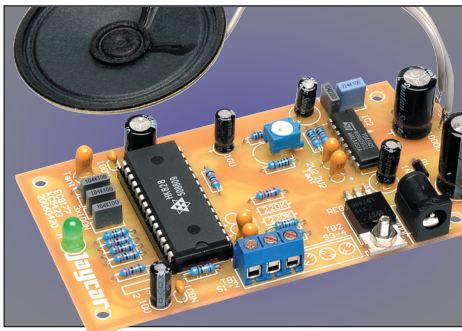
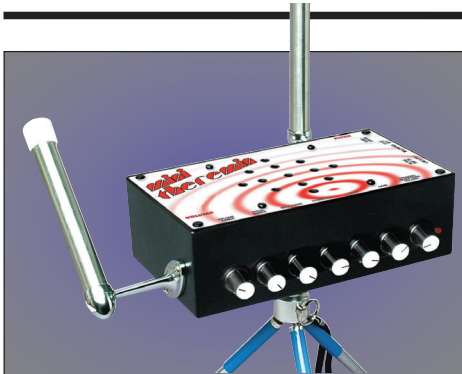
VOL. 37. No. 6 JUNE 2008

# **EPE** EVERYDAY PRACTICAL ELECTRONICS

INCORPORATING ELECTRONICS TODAY INTERNATIONAL

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Our July 2008 issue will be published on Thursday, 12 June 2008, see page 72 for details.

Everyday Practical Electronics, June 2008

## **Projects and Circuits**

- UNIVERSAL HIGH-ENERGY LED LIGHTING SYSTEM – PART 1** 10  
by John Clarke and Julian Edgar  
An incredibly versatile Luxeon LED lighting system – easy dimming, flashing and automatic switch-on
- STARSHIP ENTERPRISE DOOR SOUNDER** by Jim Rowe 22  
A project especially for 'Trekies'
- MINI THEREMIN – PART 2** by John Clarke 30  
A unique and versatile electronic musical instrument
- MONOPOLY MONEY** by Dave Geary 40  
See if you can do a better job than Wall Street
- INGENUITY UNLIMITED** Sharing your ideas with others 53  
Low Voltage Flasher

## **Series and Features**

- TECHNO TALK** by Mark Nelson 20  
Nanopower Rules
- INTERFACE** by Robert Penfold 28  
USB Port Interfacing
- TEACH-IN 2008 – USING PIC MICROCONTROLLERS – PART 8** 48  
by John Becker  
RS232 serial communication, basic use of Timer 1, plus an introduction to ADC
- CIRCUIT SURGERY** by Ian Bell 56  
More on Ground and Earth loops
- PIC N' MIX** by John Becker 58  
PIC controlling matrixed LEDs while maintaining constant brilliance
- NET WORK** by Alan Winstanley 66  
Dual play; BBC iPlayer

## **Regulars and Services**

- EDITORIAL** 7
- NEWS** – Barry Fox highlights technology's leading edge 8  
Plus everyday news from the world of electronics
- BACK ISSUES** Did you miss these? 54
- PLEASE TAKE NOTE** Circuit Surgery (April '08) 56
- CD-ROMS FOR ELECTRONICS** 60  
A wide range of CD-ROMs for hobbyists, students and engineers
- SUBSCRIBE TO EPE** and save money 63
- READOUT** John Becker addresses general points arising 64
- DIRECT BOOK SERVICE** 68  
A wide range of technical books available by mail order, plus more CD-ROMs
- EPE PCB SERVICE** 70  
PCBs for EPE projects
- ADVERTISERS INDEX** 72

**Readers' Services • Editorial and Advertisement Departments** 7



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Sales**

**177 168**

## PIC & ATMEL Programmers

We have a wide range of low cost PIC and ATMEL Programmers. Complete range and documentation available from our web site.

### Programmer Accessories:

40-pin Wide ZIF socket (ZIF40W) £14.95  
18Vdc Power supply (PSU010) £18.95  
Leads: Parallel (LDC136) £3.95 / Serial (LDC441) £3.95 / USB (LDC644) £2.95

### NEW! USB & Serial Port PIC Programmer



USB/Serial connection. Header cable for ICSP. Free Windows XP software. See website for PICs supported. ZIF Socket and USB lead extra. 18Vdc.

Kit Order Code: 3149KT - £39.95

Assembled Order Code: AS3149 - £49.95

### NEW! USB 'All-Flash' PIC Programmer

USB PIC programmer for all 'Flash' devices. No external power supply making it truly portable. Supplied with box and Windows XP Software. ZIF Socket and USB lead not incl.

Assembled Order Code: AS3128 - £44.95

Assembled with ZIF socket Order Code: AS3128ZIF - £59.95



### 'PICALL' ISP PIC Programmer



Will program virtually all 8 to 40 pin serial-mode AND parallel-mode (PIC15C family) PIC microcontrollers. Free Windows software. Blank chip auto detect for super fast bulk programming. Optional ZIF socket.

Assembled Order Code: AS3117 - £24.95

Assembled with ZIF socket Order Code: AS3117ZIF - £39.95

### ATMEL 89xxx Programmer



Uses serial port and any standard terminal comms program. 4 LED's display the status. ZIF sockets not included. Supply: 16Vdc.

Kit Order Code: 3123KT - £24.95

Assembled Order Code: AS3123 - £34.95

### Introduction to PIC Programming

Go from complete beginner to burning a PIC and writing code in no time! Includes 49 page step-by-step PDF Tutorial Manual, Programming Hardware (with LED test section), Win 3.11—XP Programming Software (Program, Read, Verify & Erase), and 1 rewritable PIC16F84A that you can use with different code (4 detailed examples provided for you to learn from). PC parallel port.

Kit Order Code: 3081KT - £16.95

Assembled Order Code: AS3081 - £24.95



### PIC Programmer Board

Low cost PIC programmer board supporting a wide range of Microchip® PIC™ microcontrollers. Requires PC serial port. Windows interface supplied. Kit Order Code: VK8076KT - £21.95



### PIC Programmer & Experimenter Board

The PIC Programmer & Experimenter Board with test buttons and LED indicators to carry out educational experiments, such as the supplied programming examples. Includes a 16F627 Flash Microcontroller that can be reprogrammed up to 1000 times for experimenting at will. Software to compile and program your source code is included.

Kit Order Code: VK8048KT - £22.95

Assembled Order Code: VVM111 - £39.95



## Controllers & Loggers

Here are just a few of the controller and data acquisition and control units we have. See website for full details. 12Vdc PSU for all units: Order Code PSU445 £8.95

### USB Experiment Interface Board

5 digital input channels and 8 digital output channels plus two analogue inputs and two analogue outputs with 8 bit resolution.

Kit Order Code: VK8055KT - £20.95

Assembled Order Code: VVM110 - £39.95



### Rolling Code 4-Channel UHF Remote

State-of-the-Art. High security.

4 channels. Momentary or latching relay output. Range up to 40m. Up to 15 Tx's can be learnt by one Rx (kit includes one Tx but more available separately). 4 indicator LED's. Rx: PCB 77x85mm, 12Vdc/6mA (standby). Two & Ten Channel versions also available.

Kit Order Code: 3180KT - £44.95

Assembled Order Code: AS3180 - £54.95



### Computer Temperature Data Logger



Serial port 4-channel temperature logger. °C or °F. Continuously logs up to 4 separate sensors located 200m+ from board. Wide range of free software applications for storing/using data. PCB just 45x45mm. Powered by PC. Includes one DS1820 sensor.

Kit Order Code: 3145KT - £17.95

Assembled Order Code: AS3145 - £24.95

Additional DS1820 Sensors - £3.95 each

Most items are available in kit form (KT suffix) or pre-assembled and ready for use (AS prefix).

### 4-Ch DTMF Telephone Relay Switcher

Call your phone number using a DTMF phone from anywhere in the world and remotely turn on/off any of the 4 relays as desired. User settable Security Password, Anti-Tamper, Rings to Answer, Auto Hang-up and Lockout. Includes plastic case. 130 x 110 x 30mm. Power: 12Vdc.

Kit Order Code: 3140KT - £54.95

Assembled Order Code: AS3140 - £69.95



### 8-Ch Serial Port Isolated I/O Relay Module

Computer controlled 8 channel relay board. 5A mains rated relay outputs and 4 opto-isolated digital inputs (for monitoring switch states, etc). Useful in a variety of control and sensing applications. Programmed via serial port (use our new Windows interface, terminal emulator or batch files). Serial cable can be up to 35m long. Includes plastic case 130x100x30mm. Power: 12Vdc/500mA. Kit Order Code: 3108KT - £54.95

Assembled Order Code: AS3108 - £64.95



### Infrared RC 12-Channel Relay Board



Control 12 onboard relays with included infrared remote control unit. Toggle or momentary. 15m+ range. 112 x 122mm. Supply: 12Vdc/0.5A

Kit Order Code: 3142KT - £47.95

Assembled Order Code: AS3142 - £59.95

### Audio DTMF Decoder and Display



Detect DTMF tones from tape recorders, receivers, two-way radios, etc using the built-in mic or direct from the phone line. Characters are displayed on a 16 character display as they are received and up to 32 numbers can be displayed by scrolling the display. All data written to the LCD is also sent to a serial output for connection to a computer. Supply: 9-12V DC (Order Code PSU445). Main PCB: 55x95mm.

Kit Order Code: 3153KT - £24.95

Assembled Order Code: AS3153 - £34.95

### Telephone Call Logger

Stores over 2,500 x 11 digit DTMF numbers with time and date. Records all buttons pressed during a call. No need for any connection to computer during operation but logged data can be downloaded into a PC via a serial port and saved to disk. Includes a plastic case 130x100x30mm. Supply: 9-12V DC (Order Code PSU445).

Kit Order Code: 3164KT - £54.95

Assembled Order Code: AS3164 - £69.95





## Hot New Products!

Here are a few of the most recent products added to our range. See website or join our email Newsletter for all the latest news.

### Bipolar Stepper Motor Chopper Driver

New bipolar chopper driver gives better performance from your stepper motors. It uses a dual full bridge motor driver based on SGS Thompson chips L297 & L298. Motor current for each phase is set using an on-board potentiometer. Can handle motor winding currents of up to 2 Amps per phase. Operates from a DC supply voltage of 9-36V. All basic motor controls provided including full or half stepping of bipolar steppers and direction control. Synchronisable when using multiple drivers. Perfect for desktop CNC applications. Kit Order Code: 3187KT - **£29.95**  
Assembled Order Code: AS3187 - **£39.95**



### Shaking Dice

This electronic construction kit is great fun to build and play with. Simply shake and watch it slowly roll to stop on a random number. Kit Order Code: VMK150KT - **£9.95**



### Running MicroBug

This electronic construction kit is an attractive bright coloured bug-shaped miniature robot. The microbug is always hungry for light and travels toward it! Kit Order Code: VMK127KT - **£9.95**



### Video Signal Cleaner

Digitally cleans the video signal and removes unwanted distortion in video signal. In addition it stabilises picture quality and luminance fluctuations. You will also benefit from improved picture quality on LCD monitors or projectors. Kit Order Code: VK8036KT - **£19.95**  
Assembled Order Code: VVM106 - **£26.95**



### PC Interface Board

This interface card excels in its simplicity of use and installation. The card is connected in a very simple way to the printer port (there is no need to open up the computer). Likewise there is no need to install an extra printer port, even if a printer is to be used. This can be connected to the card in the usual manner. Connection to the computer is optically isolated, so that damage to the computer from the card is not possible. Kit Order Code: VK8000KT - **£59.95**



Most items are available in kit form (KT suffix) or assembled and ready for use (AS prefix).

## Motor Speed Controllers

Here are just a few of our controller and driver modules for AC, DC, Unipolar/Bipolar stepper motors and servo motors. See website for full details.

### DC Motor Speed Controller (100V/7.5A)



Control the speed of almost any common DC motor rated up to 100V/7.5A. Pulse width modulation output for maximum motor torque at all speeds. Supply: 5-15Vdc. Box supplied. Dimensions (mm): 60Wx100Lx60H. Kit Order Code: 3067KT - **£13.95**  
Assembled Order Code: AS3067 - **£21.95**

### PC / Standalone Unipolar Stepper Motor Driver

Drives any 5, 6 or 8-lead unipolar stepper motor rated up to 6 Amps max. Provides speed and direction control. Operates in stand-alone or PC-controlled mode. Up to six 3179 driver boards can be connected to a single parallel port. Supply: 9Vdc. PCB: 80x50mm. Kit Order Code: 3179KT - **£12.95**  
Assembled Order Code: AS3179 - **£19.95**



### Bi-Polar Stepper Motor Driver

Drive any bi-polar stepper motor using externally supplied 5V levels for stepping and direction control. These usually come from software running on a computer. Supply: 8-30Vdc. PCB: 75x85mm. Kit Order Code: 3158KT - **£17.95**  
Assembled Order Code: AS3158 - **£27.95**



### Bidirectional DC Motor Controller



Controls the speed of most common DC motors (rated up to 32Vdc/10A) in both the forward and reverse direction. The range of control is from fully OFF to fully ON in both directions. The direction and speed are controlled using a single potentiometer. Screw terminal block for connections. Kit Order Code: 3166v2KT - **£17.95**  
Assembled Order Code: AS3166v2 - **£27.95**

### AC Motor Speed Controller (700W)

Reliable and simple to install project that allows you to adjust the speed of an electric drill or single phase 230V AC motor rated up to 700 Watts. Simply turn the potentiometer to adjust the motors RPM. PCB: 48x65mm. Not suitable for use with brushless AC motors. Kit Order Code: 1074KT - **£12.95**  
Assembled Order Code: AS1074 - **£18.95**  
Box Order Code 2074BX - **£5.95**



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**0871 717 7168**

## Electronic Project Labs

Great introduction to the world of electronics. Ideal gift for budding electronics expert!

### 500-in-1 Electronic Project Lab

Top of the range. Complete self-contained electronics course. Takes you from beginner to 'A' Level standard and beyond! Contains all the hardware and manuals to assemble 500 projects. You get 3 comprehensive course books (total 368 pages) - *Hardware Entry Course*, *Hardware Advanced Course* and a microprocessor based *Software Programming Course*. Each book has individual circuit explanations, schematic and connection diagrams. Suitable for age 12+. Order Code EPL500 - **£149.95**  
**Also available - 30-in-1 £16.95, 50-in-1 £21.95, 75-in-1 £32.95 £130-in-1 £39.95 & 300-in-1 £59.95 (details on website)**



## Tools & Test Equipment

We stock an extensive range of soldering tools, test equipment, power supplies, inverters & much more - please visit website to see our full range of products.

### Two-Channel USB Pc Oscilloscope

This digital storage oscilloscope uses the power of your PC to visualize electrical signals. Its high sensitive display resolution, down to 0.15mV, combined with a high bandwidth and a sampling frequency of up to 1GHz are giving this unit all the power you need. Order Code: VPCSU1000 - **£289.95**



### Personal Scope 10MS/s

The Personal Scope is not a graphical multimeter but a complete portable oscilloscope at the size and the cost of a good multimeter. Its high sensitivity - down to 0.1mV/div - and extended scope functions make this unit ideal for hobby, service, automotive and development purposes. Because of its exceptional value for money, the Personal Scope is well suited for educational use. Order Code: VHPS10 - **£129.95 £119.95**  
**See website for more super deals!**



**www.QuasarElectronics.com**

Secure Online Ordering Facilities • Full Product Listing, Descriptions & Photos • Kit Documentation & Software Downloads



# POPULAR KITS

These are some of our most popular kits and there is something for everyone. They are designed for ease of construction and robust reliability. All of our kits are supplied with quality fibreglass PCBs, board components and clear English instruction. Jaycar kits can be built with confidence.

## Full Function Smart Card Reader / Programmer Kit

**KC-5361 £15.95 + postage & packing**

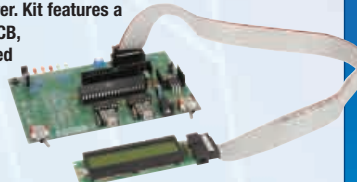
Program both the microcontroller and EEPROM in ISO-7816 compliant Gold, Silver and Emerald wafer cards. Powered by 9-12 VDC wall adaptor or a 9V battery. Kit supplied with PCB, wafer card socket and all electronic components. PCB measures: 141 x 101mm



## Audio Playback Adaptor for CD-ROM Drives

**KC-5459 £19.00 + post & packing**

Put those old CD-ROM drives to good use as CD players using this nifty adaptor kit. The adaptor accepts signals from common TV remote controls and operates the audio functions of the drive as easily as you would control a normal CD player. Kit features a double sided PCB, pre-programmed micro controller, and IDC connectors for the display panel.



## SMS Controller Module

**KC-5400 £15.95 + post & packing**

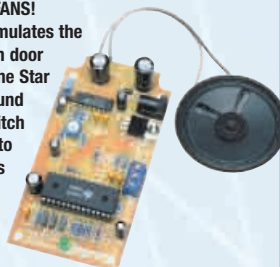
This kit will allow you to remotely control up to eight devices and monitor four digital inputs via an old Nokia handset such as the 5110, 6110, 3210, or 3310. Kit supplied with PCB, pre-programmed microcontroller and all electronics components with clear English instructions. Requires a Nokia data cable and handset.



## Starship Enterprise Door Sound Emulator

**KC-5423 £11.75 + post & packing**

Refer to EPE June.  
FOR ALL YOU TREKKIE FANS!  
This easy to build kit emulates the unique sound of a cabin door opening or closing on the Star Ship Enterprise. The sound can be triggered by switch contacts or even fitted to automatic doors. Comes with PCB with overlay, speaker, case and all specified components. 9-12VDC regulated.



## Micromitter Stereo FM Transmitter Kit

**KC-5341 £15.95 + post & packing**

This compact transmitter will connect to your CD or MP3 player and send your music to an FM radio anywhere in your house. Crystal locked to a preselected frequency to eliminate drift. Supplied with revised PCB with solder mask and overlay, case, silk screened lid and all electronic components. Some surface mounting soldering required.



## 50MHz Frequency Meter Mk II

**KC-5440 £20.50 + post & packing**

This compact, low cost 50MHZ Frequency Meter is invaluable for servicing and diagnostic work. Kit includes PCB with overlay, enclosure, LCD and all electronic components.

Features include:

- 8 digit reading (LCD)
- Prescaler switch
- Autoranging Hz, kHz or MHz



## High Performance Timer

**KC-5379 £12.95 + post & packing**

This sophisticated timer can be used as a 'one shot' for turbo timers & thermo-fans etc. or as a 'pulse' timer to squirt a water spray for 1 second every 9 seconds for emergency cooling etc. The time is adjusted via easy to use digital switches. Kit supplied with PCB, and all electronic components with clear English instructions.



## Clock Watchers Clock Kit with Blue LEDs

**KC-5416 £55.25 + post & packing**

This fascinating unit consists of an AVR driven clock circuit, and produces a dazzling display with 60 blue LEDs around the perimeter. It looks amazing, and can be seen in action on our website. Kit supplied with double sided silk screened plated through hole PCB and all board components as well as the special clock housing. Red display also available KC-5404 £41.75



## Car Kits

### Speedo Corrector MkII

**KC-5435 £14.50 + post & packing**

This kit alters the digital speedometer signal up or down by up to 99% and allows you to compensate for changes to gear & diff ratios, or tyre diameter etc. Kit supplied with PCB with overlay and all electronic components with clear English instructions.



### Digital Fuel Mixture Display

**KC-5300 £19.95 + post & packing**

This brilliant dashboard-mounting unit monitors and displays your car's air-fuel ratio in real time on a three-digit display as well as a bargraph for readings at a glance. See our website for full details. Kit includes case with silk-screened panel, PCBs, pre-programmed PIC micro, 7-segment displays, red acrylic, hook-up wire and all electronic components.



### Economy Adjustable Temperature Switch

**KC-5381 £9.75 + post & packing**

It has an adjustable switching temperature (up to 245°C) and can be configured to trigger on rising or falling temperature. Useful for running cooling fans or over-temp warning lights or alarms, etc. Kit supplied with PCB, NTC Thermistor, and all electronic components.



### Digital Fuel Adjuster

**KC-5385 £25.95 + post & packing**

This unit gives you complete control of the air/fuel ratio at 128 points across the entire engine load range and provides incredible mapping resolution and brilliant drivability. It uses the Handheld Digital Controller - KC-5386 (available separately) so there is no need for a laptop. Supports both static and real-time mapping. Kit supplied with a quality solder masked PCB with overlay, machined case with processed panels, programmed micro and all electronic components.



### High Performance Electronic Projects for Cars Book

**BS-5080 £7.00 + post & packing**

A fantastic range of 16 projects for performance cars ranging from devices for remapping fuel curves, to nitrous controllers. The book includes all instructions, components lists, colour pictures, and circuit layouts. All the projects are available in kit form, exclusively to Jaycar. Check out our website for all the details. Over 150 pages!



**More Information? Secure Ordering?**  
**www.jaycarelectronics.co.uk**



# UNIQUE TOOLS & ACCESSORIES

This is just a small selection from our massive range of hobbyist tools and accessories. See our website for our full range.

## Auto Current Tester

QP-2251 £8.50 + postage & packing

This handy test unit makes it so easy to measure currents on individual circuits. Simply plugs into any standard blade type fuseholder and provides an easy-to-read LCD of the circuit's current draw. Measures up to 20A.



## CAT III Auto-Ranging Pocket DMM

QM-1542 £14.00 + postage & packing

An advanced pocket sized DMM that is suitable for serious work. It features capacitance and frequency ranges as well as a CATIII rating and non-contact voltage detection.

- AC & DC voltage: 600V
- AC & DC current: 200mA
- Resistance: 40MOhms
- Capacitance: 100µF
- Frequency: 100kHz
- Diode & Continuity test
- Just 120mm long

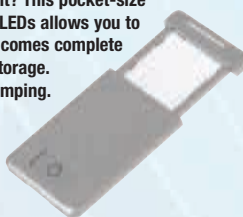


## Micro Magnifier with LED

QM-3531 £2.25 + postage & packing

Having trouble reading a street directory at night or a menu is a dimly lit restaurant? This pocket-size magnifier with super bright LEDs allows you to work or read anywhere and comes complete with a soft pouch for easy storage. Ideal to take travelling or camping.

- 2 Super bright white LEDs
- 3 X magnification with super 5 X magnifier
- Dimensions: 90(H) x 58(W) x 6(D)mm



## Self Amalgamating Tape

NM-2826 £5.75 + postage & packing

Quality NITTO brand self fusing Butyl Rubber tape that will cure to a single mass when applied to wires, cables etc. Great for insulating and waterproofing etc. 20mm x 10mtrs



## 100 pc Driver Bit Set

TD-2038 £4.75 + postage & packing

This must be the ultimate driver bit set. It includes just about every type of bit you could imagine - even one for wing nuts!



## Digital Tyre Pressure Gauge

GG-2310 £5.75 + postage & packing

Incorrect tyre pressures can cause adverse affects on handling and stopping distance and can also cause uneven or premature wear. This simple unit lets you monitor your tyre pressure simply and easily. Also includes an integrated torch and keychain attachment.

- Range: 0 - 150PSI.
- 90mm long



## Polymorph Pellets

NP-4260 £3.00 + postage & packing

Heat the pellets in hot water and mould it to any shape. It hardens at room temperature to form a tough plastic material similar to Nylon. It can be machined or heated and reformed again and again. Endless uses: model making, craft, prototyping, engineering, science, lab etc.



Supplied in a 100g bag of 3mm pellets.

## Aluminium Foil Tape - 50mm

NM-2860 £4.25 + postage & packing

To be used in any number of situations including metal patching and general sealing.



## 12 Volt ATX Computer Power Supply for Cars

XC-4876 £27.75 + postage & packing

Simply replace the existing ATX power supply in your computer with this 12 volt DC version and you can run a PC in your car as an entertainment centre to store and play an almost limitless number of MP3s and MP4 movies etc. Add one of our TFT display screens and your car computer is ready to go.



## Resistance Wheel

RR-0700 £5.75 + postage & packing

Great for experiments or selecting the best resistance for a circuit. Choose from 36 x 0.25W 5% resistors ranging from 5 ohms to 1M ohms. Comes complete with leads and insulated crocodile clips.



SEE OUR LATEST CATALOGUE FOR MORE EXCITING KITS & HOBBYIST EQUIPMENT



## Starter Projects & Tools

### Component Lead Forming Tool

TH-1810 £2.00 + postage & packing

This handy forming tool provides uniform hole spacing from 10 to 38mm. Made in USA from engineering plastic.

- 138mm long



### Pin Extractor Press

TH-2014 £3.00 + postage & packing

A handy little pin-extractor/inserter press with a 0.8mm punch. Mainly intended for taking links out of watch bands, but endless other uses for jewellery making, model making and hobbies.

- 2 spare pin punches
- Assortment of 12 pins



### Screwdriver Helper

NM-2830 £4.00 + postage & packing

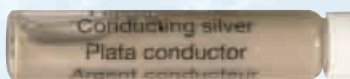
Dramatically increases the amount of torque you can apply to a damaged screw. Just apply a drop or two of Screwdriver Helper to instantly help remove or tighten screws with damaged heads.



### Silver Conductive Varnish

NS-3030 £2.95 + postage & packing

Repairs printed circuits, window antennas, window alarm loops etc. Very good conducting properties. Approximately 0.02 - 0.1 ohms/cm².



### Wire Glue 9ml

NM-2831 £2.75 + postage & packing

A conductive adhesive that enables you to make solder-free connections when you aren't able to solder. Hundreds of hobby, trade and electronics uses. Lead-free, cures overnight.

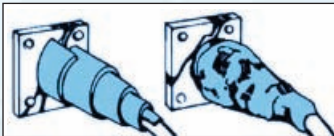
- 9ml



### Coax Seal Tape

NM-2828 £3.00 + postage & packing

This versatile material looks like ordinary PVC electrical tape but is actually a handy sealing system that fuses together to form a removable, waterproof seal once it has been applied. 12mm wide x 1.5m long.



## How To Order

- ORDER ON-LINE
- ALL PRICING IN POUNDS STERLING
- MINIMUM ORDER ONLY £10

## Post and Packing Charges

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## Celebrate a success

For those of us of a certain age (40+) a recent reunion at the *Science Museum* in London brought back fond memories. Engineers Hermann Hauser and Steve Furber, and former BBC staff John Radcliffe and David Allen met at the invitation of the *Computer Conservation Society* to discuss and reminisce about a great British success story – the BBC Microcomputer, affectionately known as the BBC 'Beeb'.

In 1980, the BBC started to devise a series of programmes to promote computer literacy. The problem, however, was that most people didn't have a computer and those that were available were either too expensive or unsuitable for the general user.

So, with great foresight, the BBC agreed to support a small Cambridge company called Acorn, build and sell a computer suitable for both parents and children. The results exceeded their most ambitious planning. They were prepared for sales of 12,000, but finally sold 1,500,000 computers.

By today's standards it was not a powerful machine. It used an 8-bit microprocessor (the 6502) running at 2MHz and started with just 16 or 32kB of RAM. Nevertheless, it ran acceptable graphics, a useable early version of Basic and even provided networking capability. While the specifications sound puny by today's standards, it was a hugely influential machine, helping to start the programming careers of many of today's software engineers.

What became of Acorn, the company that built the hardware? Well, the chances are that you use their products everyday. Acorn was not just interested in using microprocessors, but also developing them. Building on the success they achieved with the Beeb, they looked for ways to make computers more powerful and came up with designs for a sleek, simple, but very fast and efficient microprocessor architecture called RISC (reduced instruction set computing). Working with Apple Computers and others, they set up a new Cambridge-based company called ARM.

One of the most important characteristics of ARM's processors is their low power requirements, making them ideal for use in portable, battery-powered devices. The result is that nowadays, nearly all mobile phones and PDAs contain ARM CPUs – they are the most widely-used 32-bit microprocessor family in the world, even more than the better-known 32-bit Pentium 4 processors found in personal computers. So, next time you use a Nokia, Sony Ericsson or Samsung mobile phone, or listen to your Apple iPod, remember, the company that makes these products' core processors cut its teeth on the BBC 'Beeb' microcomputer, and it's not based in Silicon Valley or Japan, but Britain.



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## Too many features

**Barry Fox reports on how German software company Nero now feels that its software offers more facilities than users want**

**C**OMPUTER programs are now offering too many features, admits German software company Nero with landmark frankness. Nero sells a suite of music, photo and video editing and copying programs – over 270 million copies have now been sold worldwide.

Nero competes head on and shares the market with Roxio's Easy Media Creator. Both Nero and Roxio aggregate around twenty different programs, which try to do almost anything with multimedia that a PC user could possibly want. But the aggregation makes it harder and slower to do something simple.

### Market changes

"We were encouraged to keep adding more and more features by the companies which pre-install OEM versions of Nero on new PCs" says Patrick Peeters, Nero's

European General Manager. "The result is now almost unmanageable. People don't want one size fits all software anymore. The market has changed. In the future, we shan't add any more features. In fact, we will take things out". The first six versions of Nero concentrated on simple copying. "With Version 7 we added much more, and frankly underestimated the real life consequences. With Nero 8 we tried to take out the complexity. Now we shall take out applications."

Peeters admits that Nero has not done enough 'human testing' to watch and learn how real world users cope with the complexity. Problems over installation of the software were masked because the user does not have to do any installing when Nero comes pre-loaded on a new PC. But people who buy Nero on a disc or by download have been hitting installation problems.

### One step at a time

"There are so many different combinations of PCs and software that it is impossible to test for everything. We can't predict what may happen when there is a new version of graphics card firmware," Peeters admits.

"We are now employing an external company, which helps Apple, to do usability tests. It's very expensive and it's a very long process. We have to learn to walk before we can run, and we are only now starting to walk."

"The average life of a software company is ten years. They all start small with a simple product and then they either have to stagnate or expand. And expanding creates its own problems."

The first versions of Nero which benefit from offering less are due in September or October.

## TOUCH SENSE DEMO BOARD



Microchip has also announced the PICDEM Touch Sense 1 Demo Board (Part number DM 164125) for capacitive touch-sensing applications. The easy-to-use board comes with a PICkit Serial Analyzer and the royalty-free mTouch Sensing Solution Software Development Kit (SDK). Together, the board and supporting materials provide a complete platform for implementing capacitive touch-sensing interfaces using the highly integrated, cost-effective 8-bit Flash PIC microcontrollers.

The PICDEM Touch Sense 1 Demo Board is equipped with capacitive touch-sensing keys and sliders to enable designers to evaluate the technology in their applications using the PICkit Serial Analyzer and Windows-based mTouch Diagnostic Tool, an easy-to-use graphical user interface (GUI) that is included in the mTouch Sensing Solution SDK. Libraries, source code and other support materials that come with the board further shorten development time and reduce design costs.

The PICDEM Touch Sense 1 demo board can be purchased at [www.microchipdirect.com](http://www.microchipdirect.com). The price includes the PICkit Serial Analyzer (Part number DV1 64122) and mTouch Sensing Solution SDK. For further information, visit: [www.microchip.com/mtouch](http://www.microchip.com/mtouch).

## BIRDSONG RADIO

The surprise radio hit in the UK is a digital radio station called Birdsong. Half a million listeners a week are tuning into a DAB frequency which broadcasts a 20 minute loop of birdsong recorded in the back garden of a digital network executive. Listeners find it soothing, like the white noise from sea waves, but more musical.

The loop was recorded by 'digital evangelist' Quentin Howard, a broadcaster and engineer who is now CEO of Digital One, which won a licence to run the UK's national commercial DAB network in 1998. The birdsong loop was originally used as a test signal for DAB stations before they started programme broadcasts. It was then used to fill air-space when the popular, but cash-strapped book and arts speech station Oneworld had to shut down on 14 January 2008. The loop has been running everyday ever since, and built a cult audience, with drivers in traffic jams, stressed city-dwellers and desperate housewives leaving it running in the background.

Recent press publicity for the phenomenon looks certain to increase the listening audience. But because the station is earning no money, the birdsong cannot last. Putting adverts on the station to earn revenue would create the stress the birds relieve.

Barry Fox



## Archos TV+ home WiFi recording

Archos – the company that pretty much invented the personal or portable media player with pocket screen and hard drive – is moving into the living room and gunning for Apple iTV. The Archos TV+ home WiFi recording and streaming device – essentially an Archos PMP without a screen that connects to a TV – costs £180 for the 80GB model and £250 for 250GB. Although the prices are low, there is a hidden cost of 70 Euros for software plug-ins needed to enable all the unit's features.

The native recording and playback formats 'out of the box' are MPEG-4 video. So, TV+ owners must pay 30 Euros to download the Opera browser and Macromedia Flash 7 software needed to surf the net; it costs another 20 Euros for the 'Cinema' plug-in needed to play MPEG-2 (VOB) video files with AC3 audio; and another 20 Euros to play podcasts in H264 video with AAC audio. Because Apple will not licence Fairplay DRM, there is no chance of playing material from iTunes.

Archos is promoting the option to download movies from a website, at £3 for 24

hours viewing, with playback beginning before the download finished. But another, less well publicised feature of the TV+, makes this largely unnecessary. The TV+ can – apparently quite legally – be used to copy DVDs. When asked the direct question, Snr Marketing Manager Remi Durand confirmed that TV+ will record from a DVD player by all analogue inputs including high quality S-video and component.

"Yes, TV+ will record from a DVD player, for playback on a PMP" he explained. "We respect Macrovision and if the DVD is protected the copy will not play on a large screen TV. But most movies – even Harry Potter – have no Macrovision because the studios think it is too expensive. TV+ will then play on a living room screen."

Although the TV+ will connect to a TV set by digital HDMI cable, there is no HDTV record or play option. Resolution is limited to DVD quality. "With HDMI there is no noise, which improves picture quality", says Durand. "We will add HD when there is protected content to record and play".

Barry Fox

## FREE PCB LAYOUT SOFTWARE



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## Ethernet TCP/IP interface cards

Mirrorbow Electronics has introduced a new range of ethernet TCP/IP interface products. The range provides an ideal fast development path with control of devices via your own custom web pages. Included in the range are a pure IO interface model, an LCD display version, and a temperature and humidity option.

The products connect via ethernet to the back of your broadband router, into your network, or direct to your PC's ethernet connector. Once connected to your router for example, the on-board web pages can be accessed from anywhere on a local network, or across the internet given the correct router configurations (and a static IP address).

Being capable of web page control, the range of products is distinctive in that they allow control over custom electronics and monitoring using a web page. No drivers or specialist PC interface knowledge required, you simply need the ability to write a nice web page!

IP addresses are automatically obtained on your network over DHCP or in its absence the board itself acts as a DHCP server, so allowing fast and easy connection to a network. On-board web pages allow configuration of MAC addresses and IP if necessary, and also provide test pages to control the boards functions.

All of the products in the range include digital IOs that can be individually programmed as inputs or outputs. Thirteen of these can be configured as analogue-to-digital inputs. One of the ports can be configured as an alarm port, providing

four alarm inputs, programmable for active on high or low. When an alarm is activated, an email is sent to your configured email address (requires the board to be able to see an SMTP server).

The standard ethernet IO board has 43 digital IOs, while the display version provides 32 digital IOs and incorporates a 4x20 LCD display with commands for scroll or positional mode for display of information. The environmental version incorporates 41 or 30 IOs (depending on whether the display option is added) and a temperature and relative humidity sensor, allowing web page access to this information. Screw terminals on two of the six ports are fitted on the standard ethernet version, and as an option on the LCD versions. The other ports are on 0.1in spaced solder pads (fitted pin headers are also an option). An enclosure is available for the non-LCD version.

The display versions can independently monitor a POP3 mail box (without your PC switched on) and display the first 16 characters of the 'from' and 'subject' of the first two emails in your mailbox. Ideal for alerting you when emails arrive without having to boot up a PC!

The range starts at £44.99 (inc VAT) for the standard IO interface product, and £49.99 for the 4 x 20 LCD display version. A separate 6V 500mA power supply is required, which is available separately for £9.49. Post and Packing is a fixed charge of £4.99 on any order. The products are available online at [www.mirrorbow.com](http://www.mirrorbow.com), where the full manual and specifications are available.

## MERG Journal

*The Model Electronic Railway Group (MERG) have sent us their Spring 2008 issue. It's as bulky as ever, full of news about the Group's activities and technical bulletins. They publish the journal four times a year, and hold meetings in London five times a year at the Model Railway Club, Calshot Street, N1 9DA.*

*Their 5 July meeting will have speakers on the MERG development of the 'CBUS – a new universal layout system'. The speaker will be Mike Bolton, one of the developers of the system. Non-members are welcome.*

*For more information about MERG, contact Nicholas C Griffin, Publicity Manager, MERG, Spread Eagles, Melbury Abbas, Dorset, SP7 0DU.*

*Email: [publicity@merg.info](mailto:publicity@merg.info).*

*Web: [www.merg.org.uk](http://www.merg.org.uk).*

## EOCS Magazine

The Electronic Organ Constructors Society (EOCS) is another group who regularly send their latest journal, this time the April 2008 issue. If you are interested in similar constructional activities, contact the treasurer/membership Secretary, Ron Coates, 2 Boxhill Nurseries, Boxhill Road, Tadworth, Surrey KT20 7RJ. Tel: 01323 894909. Email: [treasurer@eocs.org.uk](mailto:treasurer@eocs.org.uk). Web: [www.eocs.org.co.uk](http://www.eocs.org.co.uk).

Remember, anything new, let us know on: [editorial@wimborne.co.uk](mailto:editorial@wimborne.co.uk)

The prototype LED lighting system being tested on a Greenspeed recumbent trike. The headlamp uses the Luxeon LED Spotlight described next month and the rear lights comprise four 1W red Luxeons, two equipped with narrow beam collimators and two with wide-angle collimators. The headlamp has a range of well over 50 metres (and will light large reflective signs at 400 metres), while the rear lights are visible from over 500 metres. Note that two Universal High-Energy LED Lighting Systems are needed to run this many LEDs!



# Universal High-Energy LED lighting System

This incredibly versatile LED lighting system uses a rechargeable battery pack and is suitable for nearly any application that needs powerful LED lighting. From a camping light to bicycle lighting, to emergency blackout lighting, this project does it all!

## PART 1: By JOHN CLARKE and JULIAN EDGAR

**M**ANY ELECTRONIC PROJECTS have been designed to run high-power LEDs – but that's all they do! This project is very different – not only can it run multiple Luxeon LEDs, but it also uses intelligent control to allow easy dimming, flashing and automatic switch-on facilities.

In addition, the control system monitors the level of the high-capacity internal rechargeable battery pack and supervises battery charging. It also uses various schemes to automatically cut the light output when the battery voltage drops below a certain level, to

give the maximum possible hours of light. The battery can be charged from a mains plugpack, a car, a solar cell or even a human-powered generator.

### Different light modes

The key to the versatility of the Universal High-Energy LED Lighting System is the ability to select different operating modes. For example, the system can be used as a normal (always on) lantern, or as a flashing lantern. It can also be used as a roadwork-style warning flasher that automatically switches on as it gets

dark, or as emergency lighting that automatically activates when mains power is lost.

In fact, no less than 11 different light operating modes are available!

The desired operating mode is selected by rotating the BCD switch on the PC board. Note that in most cases, once the mode is selected, the switch will be left permanently in that position. The system is then controlled via an external pushbutton switch.

Let's take a closer look at the various modes, as set by the BCD switch S2: **(0) ALWAYS OFF** – this can be used for



## Suggested Uses

- Auto-on garden lighting
- Auto-on blackout emergency lighting
- Intelligent multi-mode handheld torch or lantern
- Caving light
- Fishing light
- Camping light
- Intelligent bike headlight or tail-light
- Industrial warning lights

transporting the Universal High-Energy LED Lighting System.

**(1) STANDARD LIGHT** – a quick double-press of the pushbutton switches the LED on and a single press turns it off. Three quick presses from off activates a fast attention-grabbing flash.

**(2) MULTIMODE LIGHT** – a quick double-press switches the LED on and a single press turns it off. Holding the pushbutton on cycles between full brightness, a dimmed level and a slow flash. Three quick presses from an off state activate a fast attention-grabbing flash. The dimmed level is stored and reactivated at switch on.

**(3) CAMPING LIGHT** – a quick double-press switches the LED on, while a single press turns it off. Holding the pushbutton down decreases the brightness before returning to full brightness. Three quick presses from off activate a fast attention-grabbing flash. The selected dimmed level is reactivated at switch on.

**(4) WARNING FLASHER** – a quick double-press starts the LED slowly flashing and a single press turns it off. Three quick presses from off activate a fast attention-grabbing flash.

**(5) AUTOMATIC TORCH** – a quick double-press switches the LED on, with the LED intensity automatically increasing with falling light. Three quick presses from off activate a fast attention-grabbing flash and a single press switches the LED off. Unlike mode 6, this mode provides LED indication of battery condition, even when the Luxeon LED is switched off due to high ambient light levels.

**(6) PLUGPACK-CHARGED GARDEN LIGHTS** – a quick double-press switches the system on, but the Luxeon (and



The High-Energy LED Lighting System is built into a rugged diecast aluminium box. It uses high-capacity C-size 4500mAh nickel metal hydride (NiMH) cells and can drive up to 6W of Luxeon LEDs. In addition, it has intelligent charge and discharge control and user-adjustable modes that allow it to be adapted to nearly any Luxeon LED lighting use.

battery monitoring LED) stay off until the ambient light level falls. The Luxeon LED then automatically increases in intensity with falling light.

Three quick presses from off activate a fast attention-grabbing flash, with this mode operating only when the Luxeon LED is already on; ie, below the low ambient light threshold. The system is normally left on, but can be switched off with a single pushbutton press, with the battery

condition LED also then switched off.

**(7) SOLAR GARDEN LIGHTS** – this is very similar to mode 6, except that after the Luxeon LED automatically activates, it stays on for six hours or until the ambient light level rises.

**(8) ROADWORK WARNING** – a quick double-press switches the system on, but the Luxeon LED (and battery monitoring LED) stay off until the ambient light level falls. The Luxeon LED then starts

## Main Features

- Runs nearly any combination of Luxeon LEDs from 1W to 6W total power
- Self-contained high-capacity NiMH battery pack
- Rechargeable from any 8.7V to 18.6V voltage source
- Automatic control of charge rate
- User-selectable modes include automatic switch-on as it gets dark or when plugpack power is lost
- Flashing, dimming and automatic switch-off modes
- Automatic light output conservation strategies as battery charge drops
- Rugged diecast aluminium housing
- Battery level/charge monitor multi-function LED

slowly flashing. Three quick presses from off activate a faster flash.

The system can normally be left switched on (there's very low current drain when the Luxeon LED is off, as the battery status LED is also off). However, if required, the system can be switched off by pressing the pushbutton switch.

**(9) BICYCLE HEADLIGHT** – a quick double-press switches the Luxeon LED on. The LED is on when ambient light levels are low, but switches to flashing when light levels increase.

If the Luxeon LED is on and the pushbutton is held down for about three seconds, the unit changes to a 'parking flasher' mode. Three quick presses from off activate a fast attention-grabbing flash and a single press turns the system off (for more on bike lights, see the Bicycle Lighting System panel).

**(10) (A) BICYCLE TAIL-LIGHT** – a quick double-press switches the Luxeon LED on. A low-duty cycle flash occurs when light levels are low, the duty cycle increasing as light levels increase.

If the Luxeon is on and the pushbutton is held down for about three seconds, the unit changes to a 'parking flasher' mode. Three quick presses from off activate a fast attention-grabbing flash and a single press turns the system off.

**(11) (B) BLACKOUT EMERGENCY LIGHTING** – a quick double-press switches the system on, but the Luxeon LED activates only when the light level drops below a preset threshold and charger power is lost. A single press switches the system off.

**(12) (C) EXIT LIGHT** – a quick double-press switches the system on, but

the Luxeon LED activates only when charger power is lost. A single press switches the system off.

**(13) (D) MICROCONTROLLER RESET** – used if the battery is discharged to the extent that IC1 behaves erratically.

**(14) (E) LUXEON DRIVE FREQUENCY** – alters the drive frequency to the Luxeon LED.

**(15) (F) TEST** – for setting the reference to 2.49V, testing the LDR and thermistor, and setting the charging current.

In all but the *Reset*, *Test* and *Drive Frequency* modes, a quick double press is used to turn the system on, while a single press switches it off. In most modes, a fast attention-grabbing flash is also available and is activated by three quick presses of the pushbutton from off.

This fast attention-grabbing flash could be a lifesaver if something goes wrong when hiking or camping.

Of course, you aren't limited to the uses described in our mode descriptions. The camping light mode could also be used for a dimmable torch or a reading light, for example.

## Luxeon LEDs

The Universal High-Energy LED Lighting System is designed to work with Luxeon LEDs with a total rating of up to 6W. You can use 1W, 3W or 5W units, but where multiple LEDs are used they must all have the same rating (the lowest wattage LED is the one that determines the LED current).

In practice, this means that you can use up to six 1W LEDs, one or two 3W LEDs, or a single 5W LED. For example, a garden lighting system might use six 1W LEDs, while a bike headlight might use two 3W LEDs. The

only combination not permitted is five 1W LEDs, as it's not practical to drive five of these in parallel (six 1W LEDs are wired as three parallel groups of two in series).

Before building this unit, you first need to decide on the number of Luxeon LEDs to be used and their power rating. That's because the number of turns wound on the transformer, the value of a resistor and the adjustment of a trimpot all depend on the LEDs that will be driven.

In addition, the choice of LEDs determines whether they are wired in series, in parallel or in a series/parallel combination.

The higher the total power rating of the LEDs, the greater the current drain and so the shorter the battery life. However, there are major practical advantages in specifying high-wattage LEDs and then dimming or flashing them. Let's take a look at a typical use to see why this is the case.

As an example, you might be running two 3W LEDs (6W total) in a camping lantern. At full brightness, the battery pack will last something in the order of two hours – but that's at full brightness. If you have the system set to *Camping Light* mode, you can use the pushbutton to dim the LEDs substantially and in many applications, one-quarter of the available power will be quite sufficient. At this power level, the battery pack will last well over four times as long – ie, eight hours with ease.

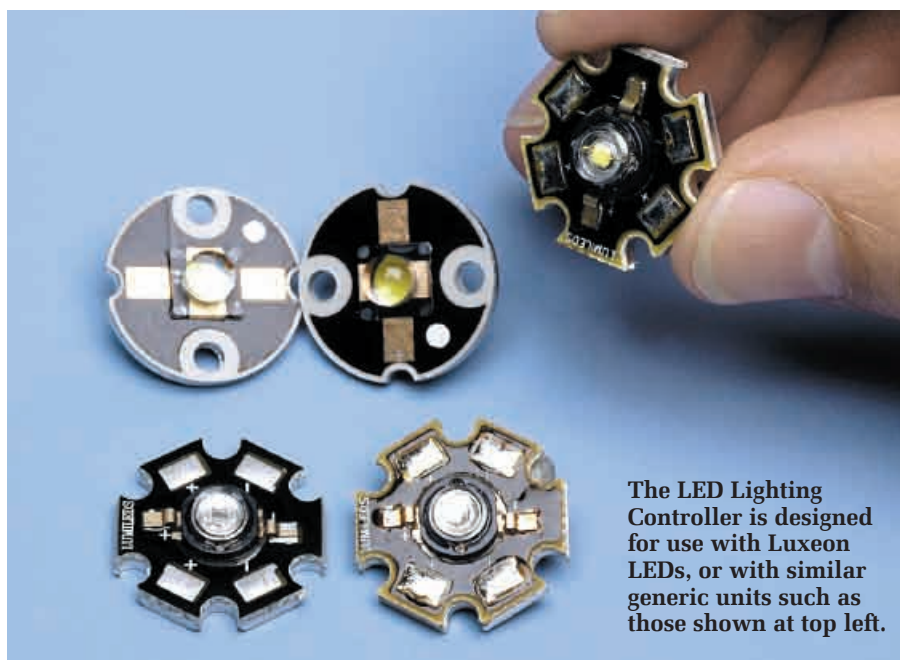
And the reason we specify 3W LEDs rather than 'one-watters'? Well, that's for when you hear some rustling in the bushes and immediately want lots of light. A few pushes of the button and you'll be illuminating the whole site!

The same idea applies when you've picked one of the flashing modes. In many cases, the duty cycle of the flash (ie, the proportion of time the LEDs are on) will be only 3%. The current drain on the battery will then be about 97% less than it would if you were running the LEDs at constant full brightness.

In this case, you can take advantage of the attention-drawing capabilities of the very powerful flash, while still retaining excellent battery life. In fact, in *Roadwork Warning* mode – where the flasher turns itself on at night and stays off in daylight – the battery life will be weeks!

Finally, in many applications it makes more sense to use multiple LEDs





The LED Lighting Controller is designed for use with Luxeon LEDs, or with similar generic units such as those shown at top left.

rather than a single high-power unit. That's because using multiple LEDs allows you to aim them in different directions and/or use different optics with each LED. For example, emergency blackout lighting usually uses two broad beam lights aimed widely, while a bicycle headlight might use a narrow beam aimed higher than a second broad lower beam.

Note that although we've referred to Luxeon LEDs throughout this article, any equivalent high-power, high-brightness LEDs (rated at 1W or more) can be used. However, all the prototypes used Luxeon LEDs and optics (eg, collimators) designed for those LEDs. *Note: the circuit is not designed for driving conventional 5mm or 3mm high-brightness LEDs.*

## Batteries and charging

Four C-size 4500mAh nickel metal hydride cells are used to power the Universal High-Energy LED Lighting System. These provide the best compromise between volume, capacity and cost.

Battery charging is automatically supervised by the microcontroller. In its default mode, all you need do is provide an 8.7V to 18.6V DC input voltage from a source capable of supplying 700mA. This means that the batteries can be charged directly from a 1A 12V plugpack, or a car cigarette lighter socket.

Note, however, that a power source with greater or less current capability

than 700mA can also be used – see the Adjustable Charging Current panel next month. If the charging voltage is outside the required range, the system automatically switches off the charge.

In operation, the unit automatically selects one of three battery charging modes. These are (1) *Fast charge*, (2) *Top-up* and (3) *Maintenance*.

Unless the user has requested a non-standard battery charge rate, the *Fast charge* mode (indicated by the battery monitor LED showing a 4Hz green flash) charges at 700mA. A timer prevents *Fast charge* mode running longer than appropriate (to prevent over-charging), the actual time depending on the charge rate.

For example, if *Fast charge* is set to operate at 700mA, the timeout is typically nine hours. Table 1 shows the time-out periods for the other charge rates. Note that the charge rate referred to here is the current supplied by the charging source. As we shall see later, this is not necessarily the battery charge current.

In addition to timing the duration of charge, the unit also monitors the battery temperature to detect an appropriate end-of-charge point. If the battery temperature rises by 20°C during charging, the charge mode switches from *Fast charge* to *Top-up*.

*Top-up* mode, indicated by a slower 2Hz green flash of the battery monitor LED, runs for one hour at half the full-charge rate (unless the full-charge is

only 100mA, in which case this rate of charge is maintained).

Finally, in *Maintenance* mode, the charging rate is set to 100mA – indicated by the battery monitor LED flashing at a 1Hz rate. Note: when the LED is flashing green, it will go red as it switches off each time. This is normal.

If the battery level falls to 1.15V/cell while in the *Top-up* or *Maintenance* charge modes, *Fast charge* is automatically reinstated. If an over-temperature condition is detected, the system switches back to *Maintenance* charge mode. If a cell over-voltage condition is detected (cell voltage greater than 1.95V), the charging system switches off until the cell voltage drops below 1.95V, at which point *Maintenance* mode is activated.

Finally, if the input power is removed during *Fast charge* and then re-applied, charging will not restart unless the cell voltage is below 1.5V per cell. Also, if the leads to the thermistor are broken, charging cannot occur.

All that might sound complicated, but in normal use, all charging is done completely automatically. All you need do is look at the indicator LED – the slower it is flashing, the greater the charge level in the battery pack.

## Flat battery strategy

The indicator LED also shows the battery level when the system is not being charged (but the power is on). It uses the following logic:

- (1) >1.2V per cell – green
- (2) >1.15V – orange
- (3) >1.1V – orange flashing
- (4) >1.05V – red
- (5) >1V – flashing red
- (6) <1V – off

The logic is easy to remember – green for good (more than 50% capacity left), orange for less than half battery capacity (not-so-good), and flashing red for bad. And if the battery LED is off, that's very bad. However, the user has plenty of warning when the battery voltage is low. That's because when the cell voltage drops below 1.05V (and the battery LED starts flashing red), the Luxeon LED output automatically decreases to half power.

Should the battery voltage fall even further, the Luxeon output switches to flashing at the 'attention-grabbing' rate and the battery monitor LED is switched off. Note, however, that if the

**Table 1: Charger time-out periods**

Fast charge rate setting	Timeout period 8.7-12.6V input	Timeout period 12.6-15.6V input	Timeout period 15.6-18.6V input
100mA	Indefinite	Indefinite	Indefinite
200mA	33h	22h	17h
300mA	22h	15h	11h
400mA	17h	12h	9h
500mA	14h	9h	7h
600mA	11h	7h	6h
700mA	9h	6h	5h
800mA	8h	5h	4h
900mA	7h	4h	3h
1A	7h	4h	3h

When connected to a power source, the battery pack fast charges until a timeout period elapses or the battery temperature rises by more than 20°C. This table shows the time-out periods for the different user-selectable charging rates versus input voltage. The default is 700mA and for input voltages below 12.6V, the charger will change from 'Fast charge' mode to 'Top-up' after nine hours.

system is set to one of the slow flashing modes, the flash rate doesn't change as the battery drops to this level.

The attention-grabbing flash rate uses a duty cycle of just 12.5% at a frequency of 2Hz, so the unit continues to provide lighting for a very long time, even after the battery is nominally flat.

Note: a single LED is used to indicate both battery level and charging rate. Normally, it will be obvious whether charge or battery level is being shown by the LED. However, if the Universal High-Energy LED Lighting System is being charged by an intermittent (eg, human-powered) generator and at the same time is powering a Luxeon, the function might not be immediately clear. In this case, there's an easy rule to remember: flashing green indicates charging is occurring – see Table 2.

## Flashing and dimming

Because the unit can flash and dim in a number of different modes, let's take a look at what actually occurs in each mode.

First, as already stated, the attention-grabbing flashing uses a 12.5% duty cycle at 2Hz. This allows the Luxeon LED to be used to light your way and/or to attract attention while using very little power. This feature is available with three quick button pushes in most modes (as well as occurring when the battery is nearly exhausted).

The modes that incorporate a specific flasher function (ie, *Multimode light*, *Warning Flasher* and *Roadwork Warning*) and also the bicycle 'parking light' use a 3.1% duty cycle at 0.5Hz. In other words, the Luxeon LED flashes once every 2s for 1/32nd of the available time. This mode draws only low average current and so battery life is excellent.

The *Bicycle Headlight* mode flashes the headlight when the light level is relatively high. This uses a flash frequency of 4Hz and a duty cycle of 25%. By contrast, the *Bicycle Tail-Light* mode flashes the light at the same frequency, but has a duty cycle that varies between 12.5% at low light levels to 50% at high light levels. In both cases, this conserves power while providing excellent visibility and illumination in all ambient lighting conditions.

Dimming is available in the *Multimode light* mode (where current is reduced to 25%) and in the *Camping Light* and *Automatic Torch* modes (where the current is reduced from 100% to 2.5% in 2.5% steps). These dimming increments are so small that the light appears to dim steplessly.

## Ambient light measurement

A number of modes require the use of an external light sensor. A light-dependent resistor (LDR) is used for this purpose. In some applications (eg, *Blackout Emergency Lighting* and

*Automatic Torch*), the LDR can be mounted on the box containing the rest of the system so that it detects the ambient light level. However, in the *Bicycle Tail-Light* mode, the LDR is primarily used to detect the headlights of cars approaching the bike from the rear. In this way, the duty cycle of the flashing tail-light increases as the cars draw nearer.

To be effective in this application, the LDR needs to be remotely mounted in a tube facing rearwards.

## How it works

Refer now to Fig.1 for the circuit details. It's based on a single microcontroller (IC1) and its custom software. As detailed above, it controls the lighting of the Luxeon(s) as well as supervising battery charging. In addition, the microcontroller also controls the Luxeon output based on the mode selected by the user.

In short, IC1 forms the heart and soul of this project.

The four C-size NiMH cells provide a nominal 4.8V supply to power the circuit. In addition, the supply for IC1 is regulated using a low drop-out 3-terminal regulator (REG1). This is needed to ensure that IC1's supply voltage is maintained at 5V even when charging, when battery voltage can rise above 7V.

## LED driver

The Luxeon LED driver circuitry is based on MOSFET Q2, transformer T1 and current feedback resistor R1. In operation, a pulse width modulation (PWM) output from pin 9 of IC1 drives Q2 on and off at a duty cycle that can be varied to set the LED current.

Q2 is a logic level MOSFET that can be fully switched on with logic level (5V) signals at its gate. Standard MOSFETs usually require at least 10V at the gate in order for the device to fully switch on, so a logic level MOSFET is best suited to this circuit since we have only a low voltage drive from IC1 to Q2.

The circuit works as follows: when Q2 is switched on, current flows through T1's primary winding. Then, when Q2 is subsequently switched off, the current through this winding (and thus its associated magnetic field) collapses and induces a voltage across T1's secondary winding. This voltage is then rectified using diodes D3-D6 and filtered by a 470µF capacitor.



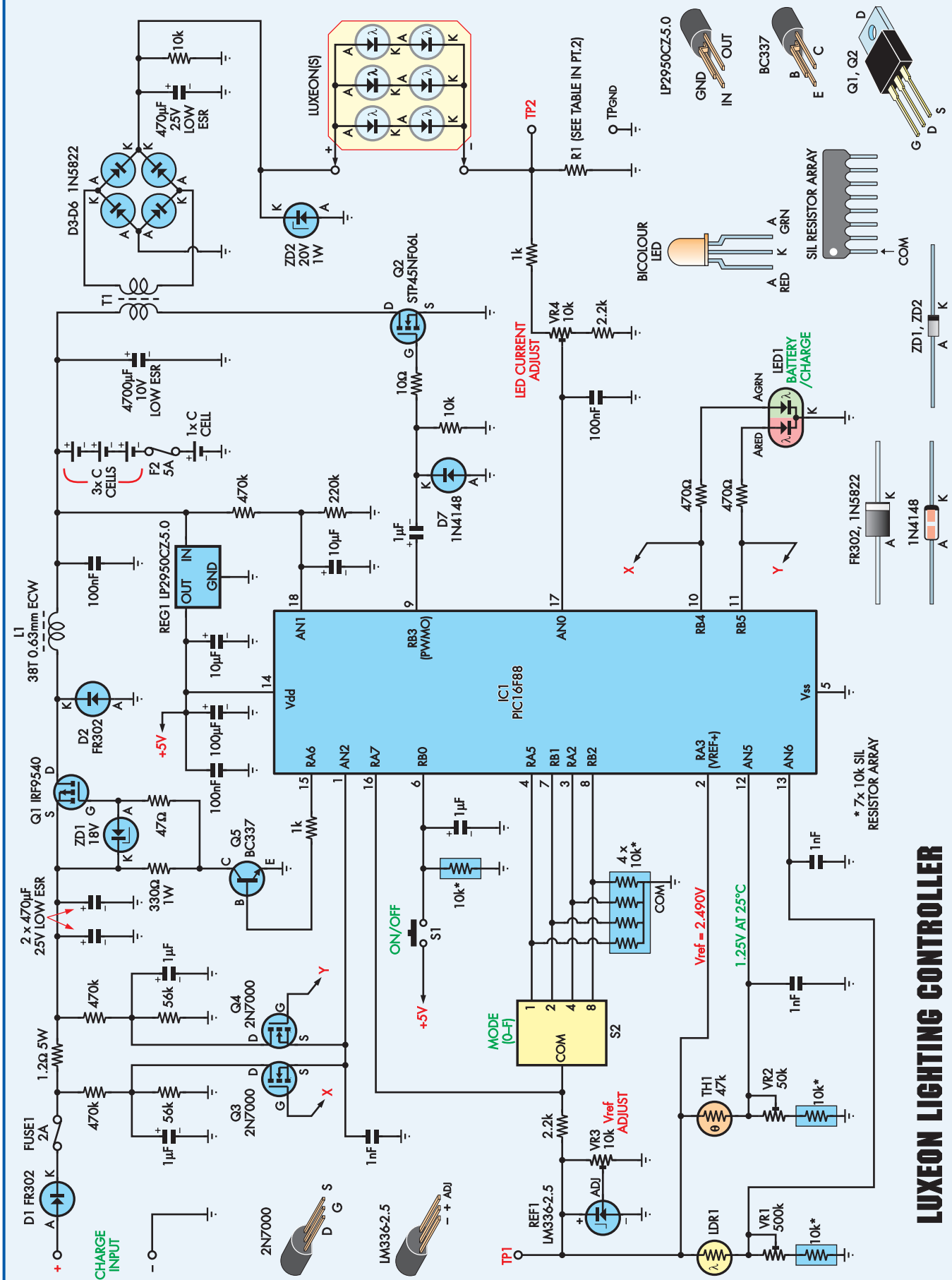


Fig.1: microcontroller IC1 controls both the charging current (via MOSFET Q1 and a filter circuit consisting of inductor L1 and diode D2) and the Luxeon LED current (via Q2). It also monitors switches S1 and S2 (Mode), the battery temperature (via a thermistor) and the ambient light level (via an LDR).

## Bicycle Lighting System

This unit can be configured to produce very effective bicycle lights – both front and rear.

Let's look at the headlight first. Bike headlights perform two functions: (1) they illuminate the road ahead for the rider (obviously); and (2) they alert motorists to the rider's presence.

The best way of alerting motorists is to flash the headlight rapidly, while the best way of showing the road ahead is to light the headlight continuously. So a headlight that automatically changes from flashing (in high ambient light) to constantly on (in low ambient light) provides the best of both worlds. The *Bicycle Headlight* mode gives just this function.

The designers of tail-lights also face a dilemma. A tail-light that flashes with a long duty cycle is more attention-getting than one that flashes with a short duty cycle. However, a short duty cycle means less total current draw from the battery and less heat build-up in the LED. This means it's best to use a short duty cycle when the cyclist is alone on the road.

This problem is easily overcome by selecting *Bicycle Tail-Light* mode. This normally flashes the tail-light with a short duty cycle, but automatically increases the duty cycle when the headlights of an approaching car are detected from behind.

The resulting DC supply drives the Luxeon LED (or LEDs), the current also passing through feedback resistor R1. The voltage developed across R1 is then sampled using a voltage divider consisting of a 1k $\Omega$  resistor, trimpot VR4 and a 2.2k $\Omega$  resistor to ground. VR4 adjusts the voltage 'seen' by IC1 at its AN0 input (pin 17).

In operation, IC1 maintains the LED current set by trimpot VR4 at a constant value. It does this by adjusting the duty cycle of the PWM switching signal applied to Q2's gate. This duty cycle can be very finely controlled in 1024 steps between fully off and fully on to control the LED brightness.

The PWM signal is normally 7.8kHz but 13kHz can be used instead. This higher frequency reduces the faint, but audible squeal produced by the transformer, however the dimming control is not as precise.

Note that the PWM output at pin 9 of IC1 drives Q2 via a 1 $\mu$ F capacitor. This AC coupling is included as a safety measure, in case IC1 locks up and sets pin 9 permanently at 5V. If this occurs, Q2's gate is held low via a 10k $\Omega$  resistor, thus preventing a short circuit with T1's primary permanently connected across the battery.

Note: IC1 could 'lock-up' if the batteries were allowed to discharge to

below 3V, at which point IC1's operation cannot be guaranteed.

Zener diode ZD2 protects the 470 $\mu$ F capacitor from instantaneous excess voltage if the Luxeon load is disconnected while being driven. In addition, the software shuts down the drive circuit and switches the unit off if the connection goes open circuit.

### LED drive strategy

As already noted, the Luxeon LEDs are supplied with current from a nominal 4.8V battery via transformer T1, which is switched on and off using Q2. This type of driver is far more efficient than using a series limiting resistor to set the LED current and also allows us to maintain the LED current as the battery voltage falls. In addition, this arrangement allows us to provide drive for a wide range of LED combinations that would otherwise be impossible to power from a 4.8V battery.

For example, a 5W Luxeon LED internally incorporates two LEDs in series, so the voltage drop across it is similar to two 3W Luxeons connected in series. This voltage drop amounts to about 6.8V. This means that a series dropping resistor between a 5W Luxeon and a 4.8V battery would not drive the LED to anywhere near full brightness.

However, with transformer T1 and Q2, the switching can be arranged to fully drive a 5W Luxeon. In this case, T1's windings need to be wound to step-up the voltage, since the 4.8V battery voltage is lower than the total LED voltage of about 6.8V.

When driven at its maximum current of 350mA, a single 1W Luxeon LED will have approximately 3.4V across it. In this case, T1 is wound to step down the voltage – ie, fewer turns on the secondary winding than on the primary – because the supply voltage is greater than the voltage required across the LED.

As previously mentioned, when driving more than one Luxeon LED, they are connected in series/parallel combinations. For example, two 1W Luxeons are connected in series and we need twice the voltage used for a single LED – ie, about 6.8V. However, the current through each LED is still set at 350mA.

Ideally, when driving more than one LED, series connect is best, so that they all receive exactly the same current. However, for more than three LEDs, this becomes impractical as the drive voltage needs to be increased to a relatively

**Table 2: LED Status vs Battery Condition**

	LED Status	Condition
Charging	Fast green flash	Fast charging
	Medium green flash	Top-up charging
	Slow green flash	Maintenance charging
Discharging	Steady green	Battery high level
	Steady orange	Battery medium level
	Orange flashing	Charge needed
	Steady red	Charge urgently needed
	Flashing red	Luxeon output halved
	Off	Luxeon output flashing

This table shows the tri-colour LED indications for the battery condition. Note that at the threshold voltages between the various conditions, the LED flash rate and/or colour may alternate until the battery voltage rises or falls sufficiently.



## Parts List– LED Lighting System

1 PC board, Code 673, available from the *EPE PCB Service*, size 104 × 79mm  
 1 diecast box, size 115 × 90 × 55mm  
 1 selection of Luxeon LEDs to suit application – see text  
 4 C-size 4500mAh NiMH cells with solder tabs  
 1 12VDC 1A plugpack (or similar)  
 2 FX2240 or equivalent pot core and bobbin assemblies (L1, T2)  
 1 sealed single-pole pushbutton switch (Farnell 312-0880, Omron B3WN-6002) (S1)  
 1 binary-coded DIL rotary switch (0-F) (S2)  
 1 LDR with light resistance of 50kΩ (LDR1)  
 1 NTC thermistor with 47kΩ resistance at 25°C  
 1 30A in-line blade fuse holder  
 2 M205 PC-mount fuse clips  
 1 M205 2A fast blow fuse (F1)  
 1 5A blade fuse (F2)  
 1 18-pin DIL IC socket  
 1 3-6.5mm IP68 waterproof cable gland  
 1 2-pin DIN panel socket  
 1 2-pin DIN line plug  
 1 red neon bezel for LDR window  
 2 TO-220 silicone insulating washers  
 2 M3 x 9mm tapped nylon spacers (cut to 4 x 4mm)  
 8 M3 x 12mm nylon screws  
 8 M3 nylon nuts  
 1 4m length 0.63mm enamelled copper wire  
 1 1m length of 5A figure-8 cable  
 1 100mm length of red or brown 7.5A hookup wire

1 100mm length of black or blue hookup wire  
 1 50mm length of red 5A hookup wire  
 1 50mm length of green 5A hookup wire  
 1 100mm length of twisted pair light-duty hookup wire  
 1 150mm length of 0.8mm tinned copper wire  
 1 100mm length of 3mm heat-shrink tubing  
 2 11mm-dia. x 0.5mm-thick PVC discs (as a gap for L1 and T1 cores) (from plastic book covers, roll-up cutting mat, etc)  
 3 100mm cable ties  
 2 200mm cable ties  
 16 PC stakes  
 1 small tube of neutral-cure silicone sealant

### Semiconductors

1 PIC16F88 microcontroller, programmed with Luxeon.hex (IC1)  
 1 IRF9540 100V 23A P-channel MOSFET (Q1)  
 1 STP45NF06L 60V 38A N-channel logic level MOSFET (Q2)  
 2 2N7000 N-channel MOSFETs (Q3, Q4)  
 1 BC337 NPN transistor (Q5)  
 1 LM336-2.5 voltage reference (REF1)  
 1 LP2950CZ-5.0 regulator (REG1)  
 1 tri-colour (green/red) 3-lead LED (LED1)  
 2 FR302 fast 3A diodes (D1, D2)  
 4 1N5822 3A Schottky diodes (D3-D6)  
 1 1N4148 signal diode (D7)

1 18V 1W Zener diode (ZD1)  
 1 20V 1W Zener diode (ZD2)

### Capacitors

1 4700μF 10V low-ESR capacitor  
 3 470μF 25V low-ESR capacitors  
 1 100μF 16V PC electrolytic  
 2 10μF 16V PC electrolytic  
 4 1μF 16V PC electrolytic  
 3 100nF MKT polyester  
 3 1nF MKT polyester

### Resistors (0.5W, 1%)

3 470kΩ                    2 470Ω  
 1 220kΩ                  1 330Ω 1W  
 2 56kΩ                    1 47Ω  
 2 10kΩ                    1 10Ω  
 2 2.2kΩ                  1 1.2Ω 5W  
 2 1kΩ  
 1 10kΩ 7-resistor 8-pin SIL array (Bournes 4608X-101) (Farnell 148-973)  
 1 0.5Ω 2W surface mount (R1) (Welwyn LR series 2512 case) (Farnell 361-0433)  
 1 0.2Ω 2W surface mount (R1) (Welwyn LR series 2512 case) (Farnell 361-0410)

### Trimpots

1 500kΩ horizontal trimpot (code 504) (VR1)  
 1 50kΩ horizontal trimpot (code 503) (VR2)  
 1 10kΩ multiturn top adjust trimpot (code 103) (VR3)  
 1 10kΩ horizontal trimpot (code 103) (VR4)

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high value and there isn't enough room to wind sufficient turns at the required wire thickness on T1 to achieve this.

As a result, we run a maximum of two LEDs in series when driving four or six LEDs. These series-connected LEDs are then connected as two or three parallel pairs, with the current shared between them. Admittedly, the current sharing may not be perfect, but it is better than just running all the LEDs in parallel.

### Charging

Power to charge the batteries is provided by an external supply, with diode

D1 providing reverse polarity protection. Fuse F1 protects against short circuits in the charger circuitry.

In operation, the charge rate is controlled by rapidly switching MOSFET Q1 on and off. This sets the duty cycle and thus the charging current through the batteries.

MOSFET Q1 is a P-channel type and is switched on when its gate (G) voltage is pulled below its source (S) voltage. It's driven by transistor Q5, which in turn is controlled via the RA6 output of IC1. When RA6 goes high, Q5 turns on and pulls Q1's gate low via a 47Ω resistor, thus turning Q1 on. Conversely, when

Q5 turns off, Q1's gate is pulled to the source voltage via a 330Ω resistor and so Q1 also turns off. Zener diode ZD1 ensures that Q1's gate-source voltage is limited to 18V if the external supply voltage is too high.

Diode D2 and inductor L1 form a step-down filter circuit. It works like this: when Q1 is switched on, current flows through L1 and charges the batteries. Then, when Q1 switches off, D2 becomes forward-biased and the energy stored in L1 continues to supply a charging current – rather like a flywheel effect. Altering Q1's duty cycle varies the charging current, to give

## Battery Amp-Hour Ratings

The NiMH cells used in this project have a 4500mAh capacity. This rating refers to the amount of current that can be drawn continuously from the cells over a 5-hour period.

For 4500mAh cells, this means that we can draw 0.9A (4.5/5) for five hours before the battery is discharged. Typically, individual cells will be at 1.25V during discharge (provided they were fully charged in the first place) but their voltage drops to around 0.9V when discharged.

In many cases, the Luxeon LED Lighting System will draw more than 0.9A from the cells. For example, this occurs when driving LEDs rated at 2W or more at their full power rating. In this case (ie, if the current drawn exceeds 0.9A), the usable cell capacity will be less than the specified 4500mAh.

There are two reasons for this. First, when drawing higher currents, the cell voltage is lower and this means that the system stops driving the LEDs at full power before the cells are fully discharged. Second, the cells dissipate power as heat when delivering high currents and so there is a loss of efficiency.

On the other hand, the capacity of the cells will be higher if the current drawn from the cells is intermittent rather than continuous. So the Universal High-Energy LED Lighting System can be used for longer periods on the one charge if the LEDs are not driven continuously until the cells are discharged, but rather used intermittently.

Calculating the expected discharge time for each Luxeon LED load is rather difficult. That's because the current drawn by the Luxeon LEDs automatically increases as the battery voltage drops over the discharge period. However, in a worse case scenario of driving 6W of LEDs continuously, full output power will be maintained for about two hours.

the various charging modes – ie, *Fast charge*, *Top-up* and *Maintenance*.

Note that this switching circuit also acts as a power converter – stepping down the input voltage to the battery voltage allows the charging current to be increased.

The charging current is monitored using a 1.2Ω 5W resistor. In operation, the voltage across this resistor is proportional to the input current and this is monitored by the AN2 input of IC1 via MOSFETs Q3 and Q4.

It works like this: two voltage dividers consisting of 470kΩ and 56kΩ resistors sample the voltage at both ends of the 1.2Ω resistor. The resulting attenuated 'input' and 'output' voltages are then filtered using 1μF capacitors and fed to the drains (D) of Q3 and Q4 respectively. By alternately switching these MOSFETs on and off, IC1's AN2 input can monitor first one voltage and then the other.

In practice, Q3 and Q4 are turned on when the RB4 and RB5 outputs alternately go high. Thus, when Q3 turns on, IC1 monitors the voltage on the input side of the 1.2Ω resistor. Similarly, when Q4 turns on, IC1 monitors the voltage on the output side. The microcontroller

then calculates the charging current and adjusts the duty cycle output at RA6 to maintain the required rate.

Switching the RB4 and RB5 outputs also simultaneously changes the function of the coloured LED – ie, from showing 'battery level' to 'charge'. As a result, each time the system switches on Q3 to measure the charger's input voltage, the battery/charge LED briefly flashes. This allows you to find the control unit in the dark!

### Battery indication

LED1 provides battery level indication. It can produce a green light, a red light or an orange light (both red and green LEDs lit) – see Table 2. IC1 monitors the battery voltage at its AN1 input (pin 18) via a 470kΩ/220kΩ attenuator.

### Voltage measurements

The voltage measurements made by IC1 are all referenced to an accurate voltage source. This is provided by REF1 which is an LM336 2.5V precision voltage reference.

In operation, current is supplied to REF1 via a 2.2kΩ resistor when RA7 goes high. Trimpot VR3 is used to set

the reference voltage to 2.490V and this is then fed to IC1's  $V_{REF+}$  input.

Note that the RA7 output is only momentarily activated (taken high) at regular intervals when the Luxeon LEDs are off, whereas RA7 is always high when the Luxeons are on. This gives a worthwhile power saving when the LEDs are off.

As well as driving REF1, IC1's RA7 output is also connected to the common (C) terminal of binary-coded rotary switch S2. S2's switched connections are normally pulled low using four 10kΩ resistors, which are part of a seven-resistor SIL package. However, if a contact is closed, its corresponding pin will be pulled high each time the common terminal is pulled high by RA7 and this sets the mode.

The LDR and the thermistor are both powered from the REF1 supply. IC1's AN6 input monitors the LDR, while AN5 monitors the thermistor. Trimpots VR1 and VR2 set the levels for the LDR and thermistor respectively.

Power switch S1 is monitored by IC1's RB0 input. This input is normally pulled low via a 10kΩ resistor, but when S1 is pressed, RB0 is pulled to +5V and the circuit toggles on or off.

### Low-power modes

IC1's internal oscillator operates at either 31.25kHz or 8MHz, depending on the mode of operation. When the circuit is ostensibly off, the oscillator operates at 31.25kHz to conserve power. In addition, RA7 is low and no current is supplied to REF1, the LDR or the thermistor.

In this state, current is drawn only by REG1 and IC1, with switch S2 and the charger input voltage monitored once every few seconds. However, if the Luxeon LED is to be driven or if charging starts, the oscillator is reconfigured to operate at 8MHz.

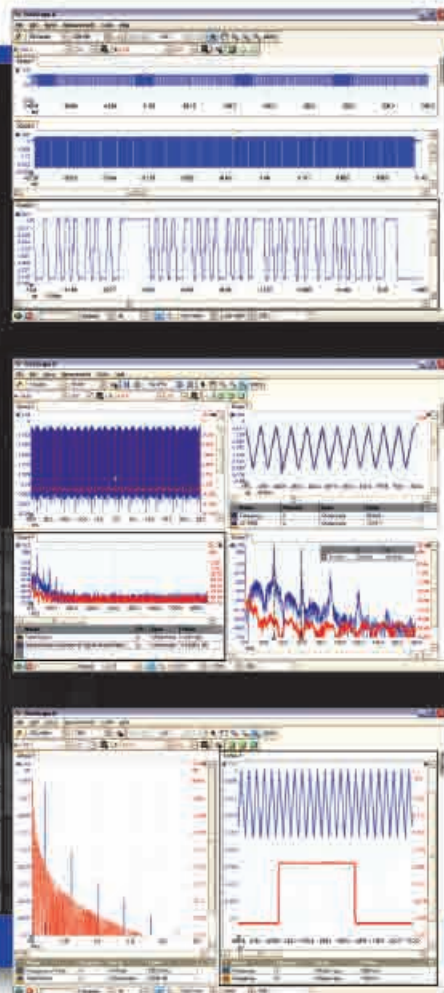
In addition, the plugpack-charged *Garden lights*, solar *Garden Lights* and *Roadwork warning* modes are all special low-power modes. When the Luxeon LED is off, the standby current in these modes is decreased to just 400μA. To help achieve this very low current draw, the battery indicator LED is also switched off.

That's all we have space for this month. Next month, we'll cover the construction and show you how to build some very effective Luxeon-powered lights.

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## NANOPOWER RULES!

**Even if you aren't an eco-warrior by nature, the sheer (and rapidly rising) cost of electricity means you need to watch the power you use. But why should consumers have to? Shouldn't appliance manufacturers give you a hand by reducing the juice that their devices guzzle? In fact, that is exactly what the enlightened ones are doing, as Mark Nelson explains.**

**T**ake a bow if you built the *EPE Standby Power Saver* featured in our October 2007 issue. Or if you have bought Bye Bye Standby, Intelliplug or one of the other gadgets that cancel standby mode when mains appliances are not in use. You're one of the good guys.

### Direct action – or indirect?

But is it wise to rely on individuals taking action themselves to control energy use? Shouldn't it be the responsibility of the manufacturers? Mark Crosier, Chief Executive Officer at Welsh company DeepStream Technologies certainly thinks so, but the problem is tougher than it looks, he argues. Smart metering is a good start, with reports of expected 10 to 15 per cent power savings possible. But the savings are not automatic, as he explains, because even with this information available, users still need to take action.

"We believe that it's time for industry and utilities to build products that make energy saving an intuitive process that requires less direct action by users and more input from stakeholders such as architects, house builders and utilities," he told trade journal *EE Times* recently. "Technology is on the way that can be designed into building structures or appliances – so that consumers can turn appliances off, or set a policy to ensure that appliances are turned off at specific times of the day or night.

"One example would be automatically turning off the TV and games console in their child's bedroom at 11 in the evening. Replicate this in a business environment, where printers, heaters and non-essential lights can be turned off outside of office hours and the potential savings are huge."

### Ecodesign initiative

The Energy-Using Products (EuP) Ecodesign Directive of 2005 is a pan-European move to protect the environment by increasing the energy efficiency of electrical devices. Products that comply with its guidelines will be marked accordingly, and it is claimed that this directive will have more of an impact on the way companies launch their products than any other piece of EU legislation. One estimate claims that these measures could achieve savings of 52 terawatt-hours a year across Europe, worth about £5.5 billion in electricity costs.

Although the precise details of implementation have not been announced yet, it is clear that manufacturers will have to provide full

consumer information on power consumption as well as dismantling instructions when the product reaches the end of its life. Enlightened manufacturers are not waiting for implementation of this directive. A case in point is Siemens, whose senior vice president of product management for home electronic products declares that ecodesign is now a market requirement and sees wall-wart power supplies as a key target. "Since most of the EuP Directive is about energy consumption, power supplies are key," he declares.

The company's Gigaset cordless phone now uses a 1.3W switching power supply unit, instead of the 3.5W device used previously, a power saving of over 50 per cent. And taking a leaf out of cellular telephony's book, these cordless phones turn down the transmission power level when used closer to the base station.

### After-life advantage

It's not only in the here and now that the EuP ecodesign directive aims to save energy. The after-life of products is important as well, and any move that makes products easier to recycle has to be a bonus. Industry groups are examining methods of achieving this and most of these are related to the materials used. But reducing the number of parts (such as screws), redesigning the methods for fastening components and simplifying assembly and disassembly are good measures to improve the eco-efficiency of a TV receiver.

Trends identified include, using a higher proportion of readily recyclable plastics (polycarbonate and ABS) plus materials sourced from renewables (bioplastics and bio-paint). Bioplastics can match existing polymers in terms of rigidity and durability and actually provide some improvements, particularly in surface finish. Bioplastics for consumer electronics are usually based on modified polylactic acid (PLA) or corn starch. It is stated that one metric tonne of bioplastics generates between 0.8 and 3.2 fewer metric tonnes of carbon dioxide than one metric tonne of petroleum-based plastics.

### True nanopower

Reducing the energy consumption of devices significantly further calls for new nanopower technologies, and while these are still a blue skies notion for most manufacturers, university research is pointing the way that further investigation might proceed.

In Ireland the Cork University College-based Tyndall National Institute is working on an ultra low-power LED lamp that could

run for 80 years on two coin-cell batteries. The real-world use that application specialist Dr Bill Henry has in mind is a light-emissive security label that could identify and authenticate particular branded consumer items. For this his team has created a micro-LED attached to a plastic optical fibre, producing a point of light smaller than a pinhead (15 microns diameter) used as a single pixel within a larger display in which each pixel is addressed independently.

The name given to this micro-LED device is FLAME, standing for future lighting applications for miniature emitters. To achieve the 80-year battery life, power consumption of the LED has been dropped to 30 nanowatts. Light extraction is about eight times higher than with a normal LED, thanks in part to etching a parabolic reflector around the light emitting structure to increase the emissive angle.

### Piezo power-shirt

The piezo effect, in which mechanical motion is converted into electrical power, is being investigated at Georgia Institute of Technology in the USA, where Kevlar fibres containing zinc oxide nanowires rub against one another to generate around 4nA (nanoamps) at 4mV. Georgia Tech's Professor Zhong Lin Wang states that a significantly improved design could generate as much as 80mW, although the efficiency of the present-day nanowire power generator is estimated to be just 17 to 30 per cent.

"The fibre-based nanogenerator would be a simple and economical way to harvest energy from physical movement," says the professor. "If we can combine many of these fibres in double or triple layers in clothing, we could provide a flexible, foldable and wearable power source that, for example, would allow people to generate their own electrical current while walking." This *power shirt* would be able to generate electricity to power small electronic devices for soldiers in the field, hikers and others, he added.

Meanwhile, a French scientist at the CEA-Leti laboratory in Grenoble, is harnessing rain power to generate piezo electricity. Thomas Jager claims that raindrops falling on a plastic membrane 25 microns thick with embedded electrodes could generate 12mW of power. Slow-falling raindrops work best, apparently, as they do not lose energy by splashing. Rain is not the only power source either, as cooling towers in air conditioning systems, produce droplets all the time. It certainly puts a new slant on hydro-electricity.



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By JIM ROWE

# Starship Enterprise Door Sounder

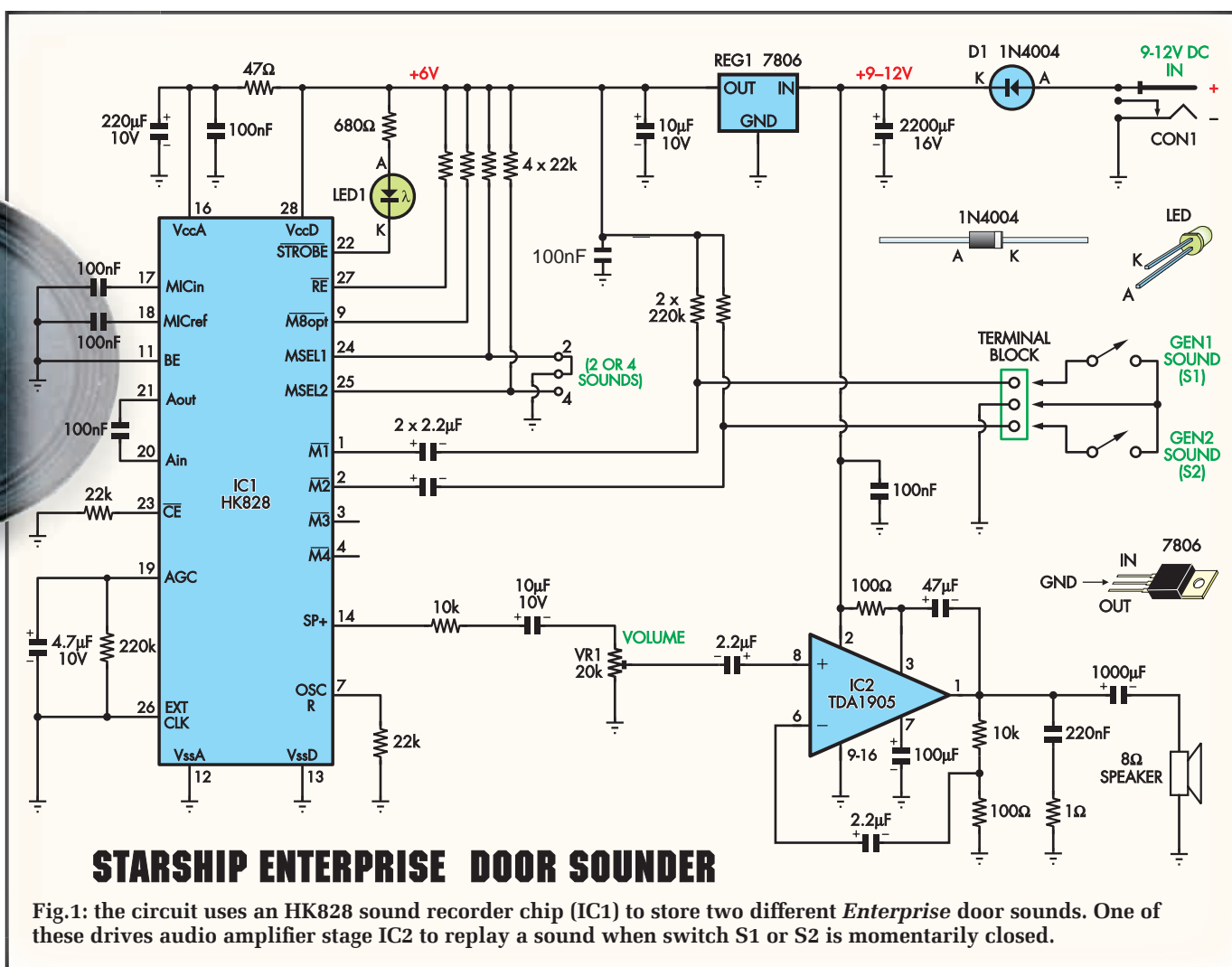
Here's a project especially for 'Trekkies'. At the closure of remote switch contacts, it recreates that distinctive 'ssshhhhhh-thump' sound of the sliding doors opening or closing on the *Starship Enterprise*. Use it for generating sound effects for your own sci-fi movies or for hooking up to a bedroom or wardrobe door so you can pretend you're aboard the *Enterprise* in deep space, going where no man has gone before!

GENE RODDENBERRY'S original TV series of *Star Trek* broke quite a bit of sci-fi ground in its day, with imaginative, thought-provoking stories and a collection of interesting characters: Captain James T Kirk, science officer Spock, engineer Scotty ("you canna' change the laws of phys-

ics, Jim") and so on. Small wonder it spawned a number of spin-off movies and a follow-on series, along with a huge following of 'Trekkie' fans who seem just as dedicated today as they were 30 years ago – no doubt helped by the release of all the original episodes on DVD.

Of course, along with those original episodes, many keen Trekkies also like to acquire *Star Trek* memorabilia: replicas of the costumes worn by the *Enterprise* crew, copies of Mr Spock's pointy ears, fake phaser guns and so on. They also like being able to generate some of the distinctive sound





effects, which helped make the first series so memorable.

So, if you have a friend or relative who's one of these dedicated Trekkies, you might want to build this project for them – or for yourself! The project is unusual for *EPE* in that it is only available as a complete kit from Jaycar – the pre-programmed recorder chip is not available separately, but we guess Trekkies will still appreciate it. It recreates the ‘ssshhhHHHh-thump’ sound that always accompanied the sliding power doors opening or closing on the *Starship Enterprise*. It can be triggered by either pressing a pushbutton or closing the contacts of an external switch (eg, a reed switch activated by a bedroom door or sliding wardrobe door). It's also quite easy to build and can be operated from a 9V battery or 12V plugpack.

## Coming up with the sound

When I was first asked (by Jaycar) to develop this project, I initially spent

some time watching old *Star Trek* episodes and listening to the sound of the *Enterprise* doors opening and closing (hard work, but somebody had to do it!). I also examined the shape of the waveform envelope and did a few spot checks of the frequency components present at various points in the waveform.

Armed with this information, I then set to work and came up with quite a fancy circuit, which generated a burst of white noise, shaped its envelope to produce a ‘ssshhhHHhh’ sound and then mixed in some low-frequency components to produce the required thump as the door closed at the end.

Well, to cut a long story short, it did work and the sound it made was a reasonable reminder of an *Enterprise* door operating.

Since this sound is less than one second long, it can easily be recorded in a solid-state voice recorder chip, like the HK828 device. The synthesised sound

produced is pre-programmed into the HK828 device. (Jaycar has copyright – see the components list).

In fact, the HK828 is capable of recording about 30 seconds of sound at its highest sampling rate, so it can easily store as many as four different sound ‘files’.

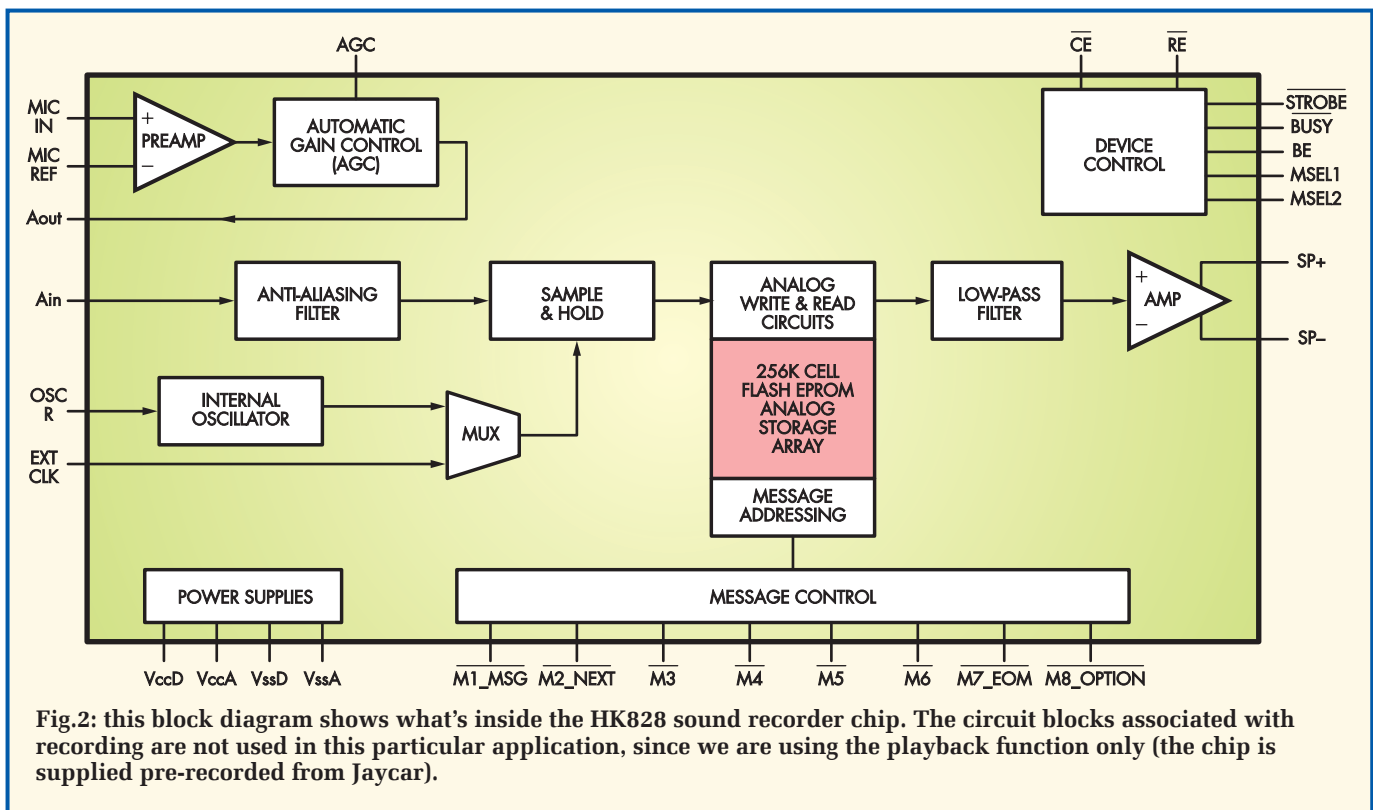
So that's the basis of this project. It's able to play back two slightly different versions of the *Starship Enterprise* door sound from pre-programmed HK828 chips.

## How it works

Fig.1 shows the circuit diagram of the unit. Here we're using the HK828 chip for playback only. That's because it will be supplied pre-programmed with the sound effect 'recordings'.

## From the inside

Because the HK828 chip forms the functional heart of the project, we'll give you a quick rundown on what's



inside it. You can see the chip's basic architecture from the block diagram of Fig.2. We won't worry about the internal circuit sections used for recording, because they're not being used in this project.

In fact, the only section on the left-hand side of Fig.2 we're making use of here is the 'internal oscillator'. This section actually generates the HK828's sampling clock for playback, as well as recording. Its frequency is determined by an external resistor (from pin 7 to ground – see Fig.1), which in this case has a value of 22kΩ to give a sampling rate of about 8.7kHz – about as fast as the HK828 can operate to achieve its best audio bandwidth.

Now, although the recorded audio is stored as samples inside the HK828, this is done using an analogue sample-and-hold system, rather than the more common digital sampling technique. This is because it stores the samples in an array of 262,144 (256K) Flash EEPROM analogue storage cells, each of which can store any of 256 different voltage levels. This gives the equivalent of an 8-bit digital recording.

As shown in Fig.2, the recording and playback of samples in the storage array is controlled by analogue write and read circuits, along with the message control and message addressing

circuits. When a recorded sound is being played back, the signals are fed through a low-pass filter to remove sampling noise and then fed to the internal output amplifier. The rest of the circuitry inside the HK828 chip is used for overall device control and mode switching.

As mentioned above, the HK828 can be configured to store and play back either a single sound 'recording' (like a tape recorder) or a fixed number of shorter recordings. In this case, it's configured to play back either of two shorter recordings.

## Main circuit

Now let's go back to the main circuit – see Fig.1. As shown, the replay audio signal is taken from pin 14 of the HK828 (IC1) and fed, via a 10kΩ series resistor and 10μF capacitor, to trimpot VR1, which is used to adjust the output volume. The audio signal is then fed via a 2.2μF capacitor to the non-inverting input of IC2, a TDA1905 audio power amplifier. This is configured to have a voltage gain of 100, as set by the 10kΩ and 100Ω resistors in the negative feedback divider.

IC2 can deliver about 800mW of audio power to an 8Ω speaker with a 9V DC supply and about 1.4W of

power with a 12V DC supply – enough to produce a convincing sound level from a 57mm diameter mini-speaker. Of course, it will produce an even more convincing sound from a larger speaker.

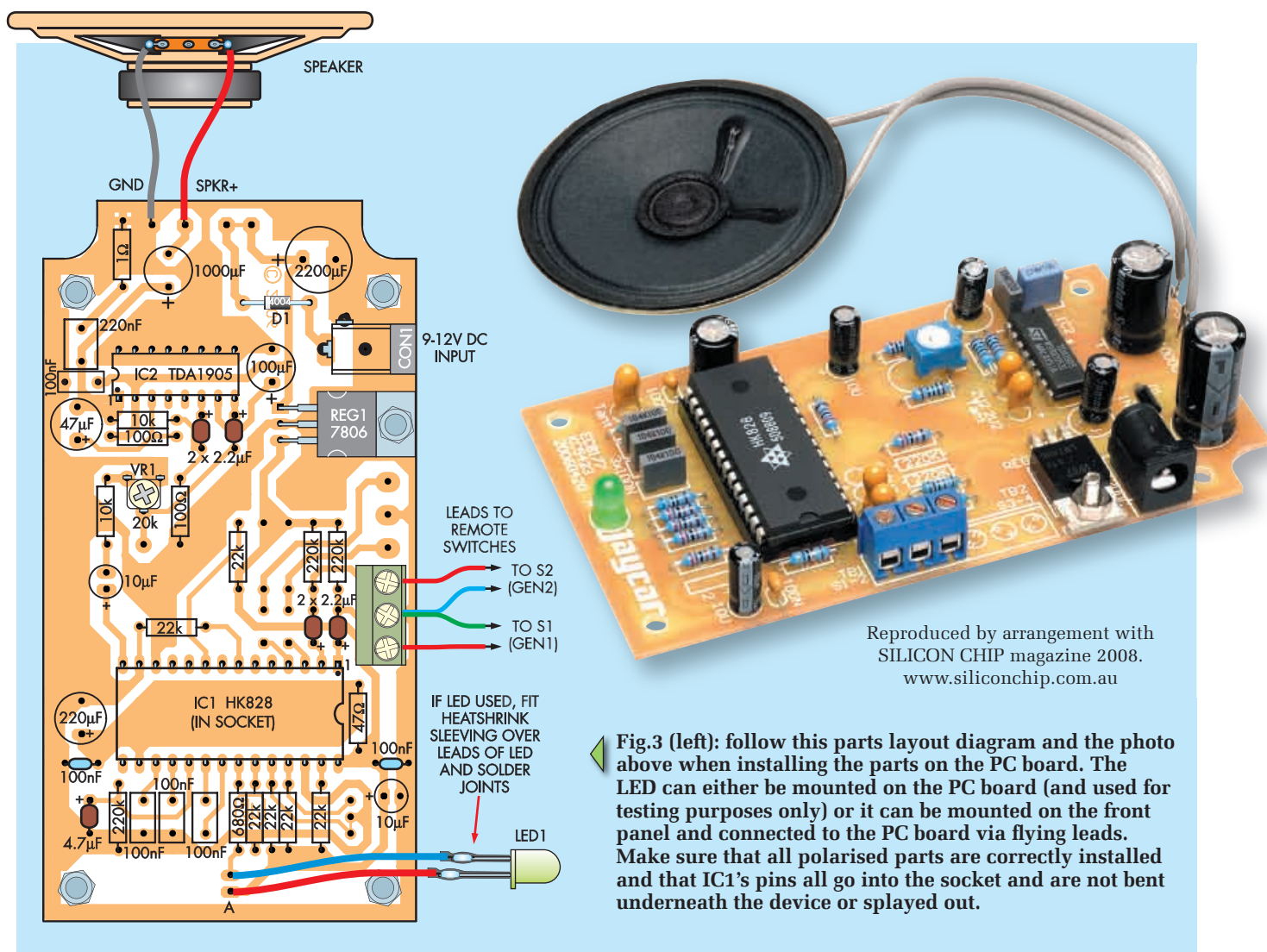
## Split memory

As stated, the HK828 chip can be configured to split its internal memory into either two or four chunks. This is done by connecting either one or the other of its MSEL pins (pins 24 and 25) to ground. In this case, the device is configured for two recorded sounds by connecting pin 24 to ground, via a small copper track on the underside of the PC board.

To trigger the HK828 into replaying one of its sound recordings, a negative-going pulse, with a duration of about 500ms, is applied to one of its trigger inputs – ie,  $\overline{M1}$  to  $\overline{M4}$ . In this circuit, only  $\overline{M1}$  (pin 1) and  $\overline{M2}$  (pin 2) are used, to replay the two recorded sounds.

The actual triggering pulses are provided by closing the contacts of either remote switch S1 or remote switch S2. In each case, this applies a negative-going pulse to the corresponding chip input via an associated 2.2μF capacitor. The capacitor then subsequently discharges again via its





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**Fig.3 (left):** follow this parts layout diagram and the photo above when installing the parts on the PC board. The LED can either be mounted on the PC board (and used for testing purposes only) or it can be mounted on the front panel and connected to the PC board via flying leads. Make sure that all polarised parts are correctly installed and that IC1's pins all go into the socket and are not bent underneath the device or splayed out.

associated 220kΩ resistor when the switch contacts open again.

This prevents the chip from being repeatedly triggered if the switch contacts remain closed. In fact, they must be opened and the capacitor allowed to discharge, before being closed again in order to retrigger the circuit.

The main idea of this is to allow you to use remote reed switches or micro-switches, so that the unit can be wired to operate automatically when you open or close a bedroom door.

When the HK828 is playing back a sound, it switches its Strobe pin (pin 22) low once every 200ms or so. This drives LED1 via a 680Ω current-limiting resistor, so that the LED 'blinks' during playback.

## Power supply

The HK828 has a maximum supply voltage of 6V. As a result, a 7806 3-terminal regulator (REG1) is used to

derive a +6V rail from the 9V to 12V DC supply used to power audio amplifier IC2. Diode D1 prevents damage due to accidental reversed polarity.

The 9-12V DC source used to power the project can be either a plugpack or battery. This must be capable of supplying about 25mA continuously when the circuit is at idle and up to 150mA or so when it is producing sound.

## Construction

Apart from the loudspeaker (and possibly LED1), all the components are mounted on a PC board measuring 111 × 57mm. This board has rounded corner cutouts at one end, so that it fits snugly inside a standard UB3-size plastic box at one end. The speaker is mounted on the underside of the box lid, while the 9V to 12V DC power source is fed in through a 2.5mm concentric DC connector mounted on the PC board.

Also on the board is a small terminal block. This accepts the leads from remote trigger switches S1 and S2; the leads entering via small holes in the side of the box.

Fig.3 shows the component layout on the PC board. Begin by fitting two PC board terminal pins at one end of the board for the connections to the speaker. Once these are in, you can also fit connector CON1 and the small 3-way terminal block.

Next, fit trimpot VR1, making sure you orient it correctly, then fit the resistors. Follow these with the capacitors, beginning with the small monolithic ceramics and then working your way through the MKT, tantalum and aluminium electrolytic types.

Remember, while the monolithic and MKT types are not polarised, the tantalum and aluminium electrolytics are polarised and must be fitted the correct way around. The wiring diagram indicates the positive lead of

# Constructional Project

## Parts List – Starship Enterprise Door Sounder

1 plastic utility box, UB3 size (130 × 67 × 44mm)  
1 PC board, size 57 × 111mm  
1 57mm dia. mini speaker, 8-ohm impedance  
1 3-way screw terminal block, PC-mount  
1 28-pin IC socket, 0.6-inch PC-mount  
1 2.5mm concentric DC connector, PC-mount (CON1)  
2 PC board terminal pins  
4 M3 × 10mm machine screws, countersink head  
1 M3 × 6mm machine screw, round head  
9 M3 nuts  
1 20kΩ horizontal trimpot (VR1)

### Semiconductors

1 HK828 sound recorder chip, pre-recorded (IC1) (Jaycar)  
1 TDA1905 audio amplifier (IC2)  
1 7806 +6V regulator (REG1)  
1 5mm green LED (LED1)  
1 1N4004 power diode (D1)

### Capacitors

1 2200μF radial elect. 16V  
1 1000μF radial elect. 16V  
1 220μF radial elect. 10V  
1 100μF radial elect. 16V  
1 47μF radial elect. 16V  
2 10μF radial elect. 10V  
1 4.7μF tantalum, 25V  
4 2.2μF tantalum, 25V  
1 220nF MKT metallised polyester  
4 100nF MKT metallised polyester  
2 100nF multilayer monolithic

### Resistors (0.25W 1% carbon film)

3 220kΩ      2 100Ω  
6 22kΩ      1 47Ω  
2 10kΩ      1 1Ω  
1 680Ω

### Where To Buy A Kit

This project was sponsored by Jaycar Electronics, who own the design copyright. A complete kit of parts is available from Jaycar – Cat. KC-5423.

each polarised capacitor with a small '+' symbol.

One point to watch with the 100nF capacitors is that two of these are multilayer monolithic ceramics, while the remaining four are the larger rectangular MKT type. The monolithic capacitors go in the indicated positions at either end of IC1, while the MKT types go in the remaining positions.

Once the capacitors are all in position, fit diode D1. This is again polarised, so make sure you orient it as shown. That done, install IC2, which should be soldered directly into the board. This is important for

its stability, and also improves heat dissipation.

By contrast, IC1 plugs into a 28-pin socket. Be sure to install this socket with its 'notched' end towards the 47Ω resistor, to guide you in plugging in the HK828 chip. When the socket pins are all soldered to the board pads underneath, you can plug IC1 into the socket. Be sure to do this without damaging any of its pins.

LED1 can either be mounted on the PC board (as in the prototype), or it can be mounted on the front panel and connected to the PC board by flying leads (as in Fig.3). If you choose the latter

option, you will have to drill an extra hole in the front panel and secure the LED using epoxy adhesive.

Note that the flying leads for LED1 are soldered directly to the board rather than to PC board pins.

The final component to fit to the board is regulator REG1, which is mounted horizontally. To do this, first bend its leads downwards by 90° about 6mm from the regulator package. That done, fasten it in place using an M3 × 6mm machine screw and nut, and then solder its leads to their respective board pads.

The PC board assembly is now complete and you can fit the wires used to connect the speaker. These speaker wires can be made from a 110mm length of light-duty figure-8 flex.

### Final assembly

The PC assembly is now ready to be mounted into the box. Before doing so though, give it a careful inspection to make sure that you haven't made any bad solder joints or left solder bridges shorting between tracks or IC pads. It's also worth double-checking that you've fitted all polarised parts with their correct orientation.

Once you're satisfied that everything is correct, the board can be mounted inside the box. This is secured using four M3 × 10mm countersink-head machine screws, which are passed up from the underside and secured using star lockwashers and M3 nuts, which also act as spacers. The board is then lowered onto these 'spacers' and secured using four more M3 nuts.

The speaker is mounted on the rear of the box lid, behind an array of holes drilled in the lid to let the sound out. It is held in place using 'Araldite' or a similar epoxy cement, applied to the front of the speaker's outer rim before introducing it to the rear of the lid. Once it's in place, you can apply

### Table 1: Resistor Colour Codes

	No.	Value	4-Band Code (1%)	5-Band Code (1%)
□	3	220kΩ	red red yellow brown	red red black orange brown
□	6	22kΩ	red red orange brown	red red black red brown
□	2	10kΩ	brown black orange brown	brown black black red brown
□	1	680Ω	blue grey brown brown	blue grey black black brown
□	2	100Ω	brown black brown brown	brown black black black brown
□	1	47Ω	yellow violet black brown	yellow violet black gold brown
□	1	1Ω	brown black gold gold	brown black black silver brown



a bead of the cement around the rim for good measure. Place the assembly aside for a few hours to allow the cement to cure.

When the epoxy cement has cured, solder the free ends of the speaker connection wires to the speaker lugs. That done, pass the bared ends of the connecting leads for the remote trigger switches (S1 and S2) through the holes in the lower side of the box and connect them to the terminal block using the screws. Note that the 'earth' wires from both switches connect to the centre hole of the terminal block. It's a good idea to twist them together before pushing them in and tightening the screw.

The project is now ready for checking and adjustment.

### Checking and adjustment

Before applying power, adjust trimpot VR1 to roughly the middle of its range. That done, connect a 9-12V DC power supply to CON1 and touch the ends of the connection wires for S1 together briefly. You should immediately hear the recorded door sound, lasting almost a second.

When it ends, try touching the ends of the wires for S2 together, to produce the second sound recorded on the HK828. LED1 should blink while either sound is being played.

You should be able to adjust the volume of the sounds up or down to the level you want using trimpot VR1. This is the only adjustment to

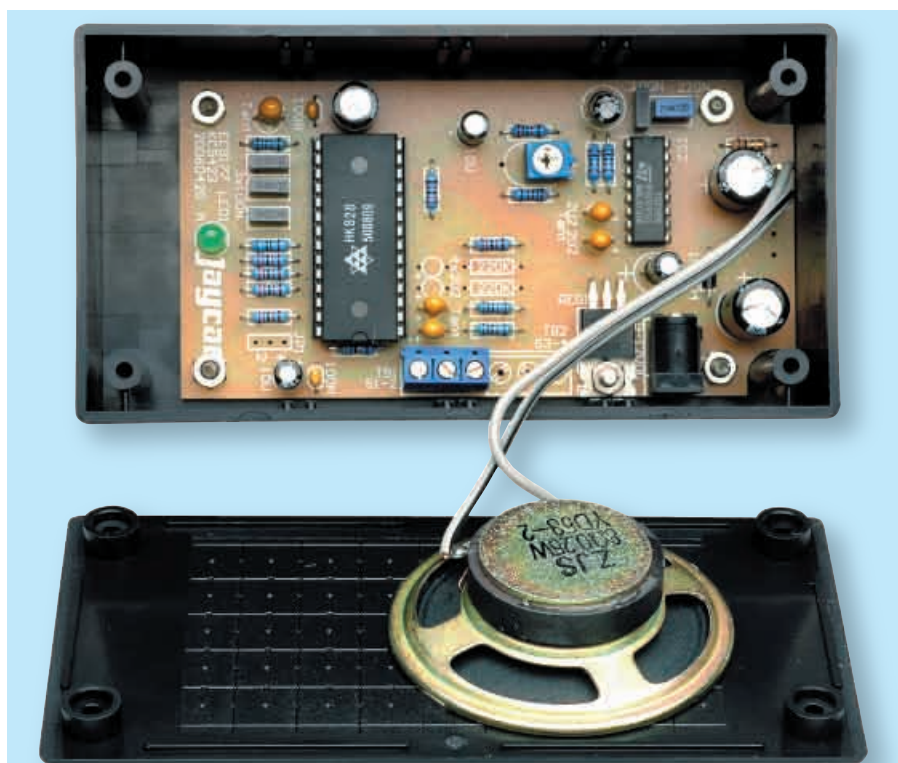


Fig.2: the circuit board fits neatly inside a standard UB3-size plastic case, and is secured using M3 × 10mm machine screws and nuts – see text. The loudspeaker is secured to the lid using epoxy adhesive.

be made, so once you've found the right volume setting, the unit can be completed by screwing on the box lid using the four self-tapping screws provided.

That's it! Your Door Sounder is now finished and ready for use. 'Beam me up, Scotty!'

EPE



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# INTERFACE

Robert Penfold



## USB PORT INTERFACING

In the previous *Interface* article, the subject of interfacing via a USB port and a virtual COM (RS232C) serial port was introduced, and this topic will be considered further this month. The main advantage of this method is that it provides a relatively simple means of interfacing via a USB port, since some programming languages have specific support for serial ports. The new COM port effectively becomes a conventional one, after the USB to serial port adapter has been installed into Windows.

It is not quite the same as a normal serial port though, since its registers do not appear in the input/output map, and cannot be directly accessed in the same way as the registers of a standard serial port. However, there is no problem if the port is accessed via the operating system, which will be the case when utilising the built-in support of a programming language such as Visual BASIC.

Some PCI add-on serial and parallel ports are supplied with software that enables the registers to be accessed just like normal port registers, but I have not encountered anything of this type with USB serial or parallel ports. Anyway, even where some form of pseudo-direct access is available, it is probably better to ignore this method and use the built-in facilities of the programming language.

### Hobson's choice

The reason for using a USB port is that it is increasingly common for modern PCs to not have standard serial or parallel ports, leaving the USB ports as the only practical method of connecting your own gadgets to a PC. Of course, a project that is designed to work via a USB to serial converter will work just as well with a standard serial port, with no changes to the software being required.

Whichever method is used, the software must be set to use the correct COM port. The port numbers are assigned automatically by the operating system. When using Windows, it is possible to obtain this information via the usual routes, such as Device Manager and the System Information utility.

It is also possible to have the conversion hardware built into the PC add-ons, but it is simpler and almost certainly cheaper to use one of the ready-made units. These are available from the larger computer stores, and can also be obtained at very low cost from computer fairs or on eBay. The one I obtained from an eBay seller (Fig.1) cost rather less than the postage and packing charge.

This device came complete with drivers for Windows ME and XT, but not Vista. However, it was recognised and installed automatically when connected to a PC running Vista. Apparently, some of these units

are not Vista compatible, so when using this version of Windows it is essential to choose one that is. The converter is powered from the PC's USB port, but there is power supply output from the RS232C port. However, a +5V supply can be obtained from another USB port.

Using a USB-to-serial converter is a relatively easy way of interfacing via a USB port, but it is not entirely clear-cut. Using a serial port has always been something less than straightforward. A USB-to-serial convert avoids the complications of USB interfacing, but it introduces the foibles of serial interfacing.

It is not quite a case of 'out of the frying pan and into the fire', but there are several points that have to be addressed when using a serial interface. One obvious drawback is that a serial port, unlike a parallel type, does not provide any normal input and output lines. These must be provided by some additional hardware, which these days is generally based on a microcontroller.

### Correct rate for the job

An important point that must not be overlooked is that correct interfacing to a serial port is only possible if the software and hardware that provides the serial-to-parallel conversion are set for the same baud rate and word format. The baud rate is simply the rate at which the serial data is transmitted, and it is the number of bits per second.

A high rate is needed in order to provide reasonably fast transfer rates. The highest normal rates are 9600 and 19200 baud, which give transfers at up to about one and two kilobytes per second respectively.

However, most PC serial ports can handle a maximum of at least 115000 baud, which gives a more useful transfer rate of around 11 kilobytes per second.

It is best not to use high baud rates unless it is really necessary to do so. Where (say) a sensing project will supply two bytes of data every few seconds, there is little point in using the highest baud rate that can be squeezed from the peripheral gadget and the PC. A modest rate of about 4800 or 9600 baud is more than adequate for a task such as this, and gives good reliability without the need for restricted cable lengths and (or) very high quality connecting cables.

### Word format

The word format controls the way in which the serial data is transmitted, and there is always one start bit. This is used to tell the receiving equipment that a byte of data is about to be sent, and it is followed immediately by the data bits. There can be anything from five to eight data bits, but in a computer context only seven-bit and eight-bit formats are normally used. Seven-bit formats are adequate for ASCII codes, but in the current context it will usually be necessary to exchange bytes of data, which obviously requires eight data bits to be used.

There can be either one or two stop bits, and these are really just included to provide a gap between the on set of data and the next. There is also the option of using parity checking, which can be of the odd or even variety. This is a rather low-tech form of error checking that is not usually worthwhile. Any eight-bit word format should suffice, but one start bit, eight data bits,



Fig.1. A USB-to-serial port converter looks like a simple lead, but there is some electronics in the serial port connector. It is powered from the USB port but there is no supply output on the serial port



one stop bit, and no parity checking is the simplest and uses the fewest number of bits. It is therefore preferable in applications where the fastest possible data transfers are required.

## Connections

A full RS232C serial interface has numerous lines available, most of which have obscure functions that are of little or no relevance in normal computer interfacing. You have to bear in mind here, that this form of interface has its origins back in the days of teletype machines that were more electromechanical than electronic devices.

The serial port of a PC is a streamlined version of an RS232C port that uses a 9-pin D connector in place of the original 25-pin type, and has little more than the bare essentials needed for proper two-way communication (Fig.2).

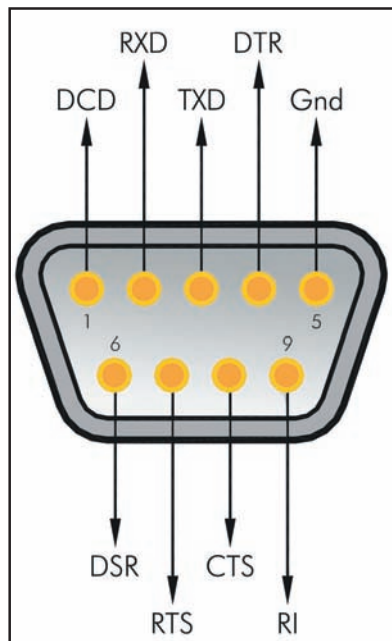


Fig.2. A PC RS232C serial port is a simplified version of the standard port, but it still has more lines than are normally needed for add-on projects. Only the RXD, TXD, and Gnd terminals are normally required

All that is needed for basic two-way communication is a simple three-wire interconnection carrying the ground (earth) connection and cross-coupling the TXD (transmitted data) and RXD (received data) terminals. The other terminals of the port are mainly concerned with handshaking, which is just a means of regulating the flow of data so that neither device receives data at an excessive rate that it cannot handle. There are facilities for hardware handshaking, and for the software variety, which is also known as XON/OFF handshaking.

It is unlikely that any form of handshaking will be required in the current context, since the maximum rate at which data can be sent is very slow by the standards of current PCs. Data received at a few kilobytes per second should not really trouble a PC that can quite happily digest data from a flash card or disk drive at about a thousand times that rate. The hardware in the PC add-ons is also likely to be fast in comparison to an RS232C serial port.

If handshaking should be required for some reason, it is usually better to make your own arrangements and incorporate it in the project's software, rather than using the inbuilt facilities of the port. With the peripheral gadget based on a microcontroller it is possible to use quite sophisticated dialogues between the PC and the peripheral device, should it prove necessary. Fortunately, in most applications the data can simply be sent as and when necessary.

In theory, a PC serial port should transmit data without any problems if no form of handshaking is selected. In practice, there can sometimes be problems with data being buffered until the appropriate level is received on a handshake input. The standard solution to the problem is to cross-couple the port's handshake lines. This requires connections from the CTS (clear to send) and DSR (data set ready) terminals to the RTS (request to send) and DTR (data terminal ready) terminals respectively. When initially experimenting with a serial port, it can be useful to connect the TXD output to the RXD input. With this link in place it is possible to send data from the port and read it back, but this should not be possible with the link removed.

## Setting parameters

Whether using Visual BASIC 6.0, 2005, or 2008, there is no serial port support by default. With Visual BASIC 2005 and 2008 it is necessary to add the SerialPort component to the form, and with Visual BASIC 6.0 it is a component called MSCOMM that must be added. MSCOMM was not included with all versions of Visual BASIC 6.0, but it should be present when using the Professional edition.

There is no serial port support in the NET versions of Visual BASIC that were released between version 6.0 and the 2005 edition. The SerialPort component is included with the free Express editions of Visual BASIC 2005 and 2008, so it is not essential to have a commercial version of this programming language in order to write software that uses the serial ports.

Using the MSCOMM component for serial interfacing has been covered in previous *Interface* articles, and elsewhere in *EPE*, although not recently. The MSCOMM and SerialPort components have many similarities, which is not surprising, as they provide the same basic function. Both avoid the need to continuously poll for fresh data when receiving, and can instead generate an event when there is fresh data available.

They are different components though, and the SerialPort component is certainly not a 'pin-for-pin' replacement for MSCOMM. Due to the changes in the Visual BASIC language in recent years this would probably not be a practical proposition.

The SerialPort component does not appear on the form when it is added, but like a visible component its parameters can be set via the Properties window, as can those of MSCOMM. Fig.3 shows the properties window for the SerialPort component, and a range of parameters can be set here. Most of them can simply be left at the default settings, but some will probably require adjustment. The PortName is the port that will be used, and is COM1 by default. An add-on USB serial port is more likely to be COM3 or COM4, and where appropriate the name must be changed.

The word format settings might have to be changed, but the default of eight data bits, one stop bit, and no parity is the one that will normally be used with PC add-ons. Where appropriate, the baud rate must be changed from 9600 to the one used by the add-on gadget.

The default setting is for no handshaking, but it is as well to check that this is set correctly. An error here could result in a lack of data flowing from the port. If preferred, most of the ports parameters can be set in the program, and the settings used in the program will, of course, override those set in the properties window.

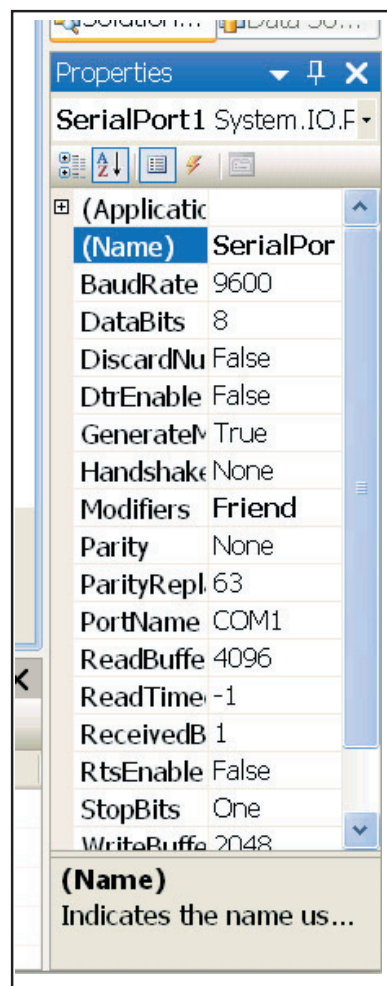


Fig.3. The Properties window enables the serial port's parameters to be set. These parameters can also be set in the software, which will override the settings in the properties window

## Open and shut

It is not possible to read from a COM port or write data to it until it has been opened. This is one example where using the SerialPort component differs from the direct addressing approach. The idea is to avoid conflicts by ensuring that a port is only accessed by one program at a time.

Once a program has opened a port, it is not possible for another program to access the port. At least, the port cannot be accessed by other software until the original program has closed the port. It can then be opened and used again by another program.

In the next article, the nitty-gritty of using the SerialPort component will be covered.

PART 2: By JOHN CLARKE

# mini Theremin



**LAST MONTH, WE DESCRIBED THE FEATURES OF THE MINI THEREMIN, TOGETHER WITH FULL CIRCUIT DETAILS. THIS MONTH, WE SHOW YOU HOW TO BUILD IT, AND DESCRIBE THE ADJUSTMENT PROCEDURES.**

**B**UILDING THE MINI THEREMIN is straightforward; virtually all parts (except for the loudspeaker and switches S1 and S2) are mounted on a PC board (code 670, size 188 × 103mm). This board is available from the *EPE PCB Service*. The board is housed in a plastic UB2 utility case measuring 197 × 113 × 63mm.

Fig.5 shows the assembly details. Begin by carefully checking the PC board for any defects (eg, shorts between tracks or broken tracks). Check also that all the hole sizes are correct for



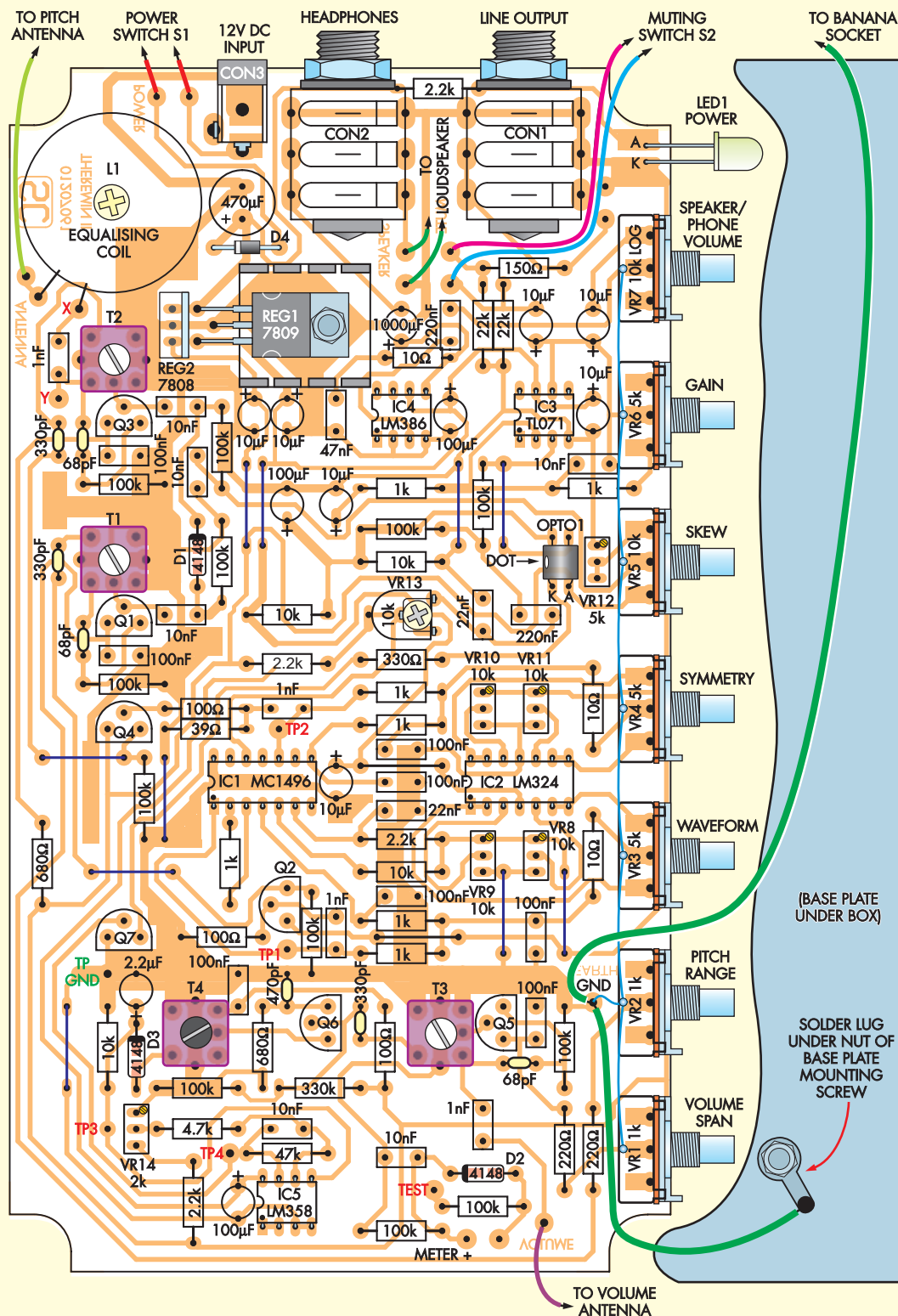


Fig.5: install the parts on the PC board and complete the wiring as shown here. Note that the pitch antenna lead should initially be connected to point 'X' (near T2), so that the equalising coil is bypassed – see text.

the various parts. In particular, check the hole sizes for the 6.35mm jack sockets, the DC power socket, the IF coils and the potentiometer mounting

holes and redrill the holes to a larger size if necessary.

Note also that the corners of the PC board need to have cutouts

– as shown in Fig.5 – to clear the four lid-fastening corner pillars in the case. If necessary, these can be cut using a small hacksaw and

## Table 1: Resistor Colour Codes

	No.	Value	4-Band Code (1%)	5-Band Code (1%)
□	1	330kΩ	orange orange yellow brown	orange orange black orange brown
□	10	100kΩ	brown black yellow brown	brown black black orange brown
□	1	47kΩ	yellow violet orange brown	yellow violet black red brown
□	2	22kΩ	red red orange brown	red red black red brown
□	4	10kΩ	brown black orange brown	brown black black red brown
□	1	4.7kΩ	yellow violet red brown	yellow violet black brown brown
□	4	2.2kΩ	red red red brown	red red black brown brown
□	6	1kΩ	brown black red brown	brown black black brown brown
□	2	680Ω	blue grey brown brown	blue grey black black brown
□	1	330Ω	orange orange brown brown	orange orange black black brown
□	2	220Ω	red red brown brown	red red black black brown
□	1	150Ω	brown green brown brown	brown green black black brown
□	3	100Ω	brown black brown brown	brown black black black brown
□	1	39Ω	orange white black brown	orange white black gold brown
□	3	10Ω	brown black black brown	brown black black gold brown

carefully filed to shape using a 'rat-tail' file.

Begin the board assembly by installing PC stakes at the eight external wiring points, test points (TP1 and TP2) and the GND point (adjacent to VR2). In addition, PC stakes are used to terminate the leads from the equalising coil (L1). That done, you can install all the wire links using 0.7mm tinned copper wire.

Note that the wire links all have a 12.5mm lead spacing. The assembly will be much faster if you cut a 12mm-wide metal or wooden jig and use this as a spacer to bend the link leads.

Follow the links with the resistors, using the colour codes in Table 1 as a guide to selecting values. It is also a good idea to use a digital multimeter to check each resistor before it is installed, as some of the colours can be confusing.

## Table 2: Capacitor Codes

Value	µF	Code	EIA Code	IEC Code
220nF	0.22µF	224		220n
100nF	0.1µF	104		100n
47nF	0.047µF	473		47n
22nF	0.022µF	223		22n
10nF	0.01µF	103		10n
1nF	0.001µF	102		1n0
470pF	NA	471		470p
330pF	NA	331		330p
68pF	NA	68		68p

The ICs, including the 4-pin optically-coupled LDR (OPTO1), can go in next, followed by the diodes. **Make sure that all these parts are positioned correctly – OPTO1 goes in with the dot on its body orientated as shown in Fig.5 (note: the pin numbering shown on the pinout diagram in Fig.4 last month is incorrect).** The capacitors can then be installed (see Table 2) but watch the polarity of the electrolytics.

The JFETs and transistors are next on the list. Note particularly that Q6 is a BC337, while Q7 is a BC327. The remainder are all 2N5484 or 2N5485 types – be sure to use the correct type at each location.

Once those parts are in, the trimpots can all be installed. Orient the top-adjust multiturn types with the adjusting screw at top, as shown in Fig.5. The IF coils can go in next. Make sure that the black-cored can goes in the T4 position. The three white-cored cans go in the T1 to T3 positions.

Now install the two 3-terminal regulators (REG1 and REG2). As shown, REG1 (7809) is mounted horizontally, with its metal tab secured to a small heatsink and to the PC board using a machine screw and nut.

To do this, first bend REG1's two outer leads down by 90°, about 8mm from its body, and its middle lead down by 90°, about 6mm away. It can then be installed along with its heatsink on the PC board and secured using an M3 × 6mm machine screw and nut, after which its leads can be soldered.

Note that the leads are soldered last of all. Do not solder the leads before fastening the regulator to the PC board, otherwise the PC pads may crack or lift due to stress as the screw is tightened.

No heatsink is required for the 7808 regulator. It simply mounts vertically with its metal tab towards REG1.

Next, install the 6.35mm jack sockets and the DC power socket. Note that we have specified high-quality 6.35mm sockets here. These have a shorter threaded bush than other commonly-available units, which will clear the side of the case when the PC board is installed.

Note: standard sockets are not suitable because they have a longer bush. This would protrude through the side of the box, making it impossible to install the PC board.

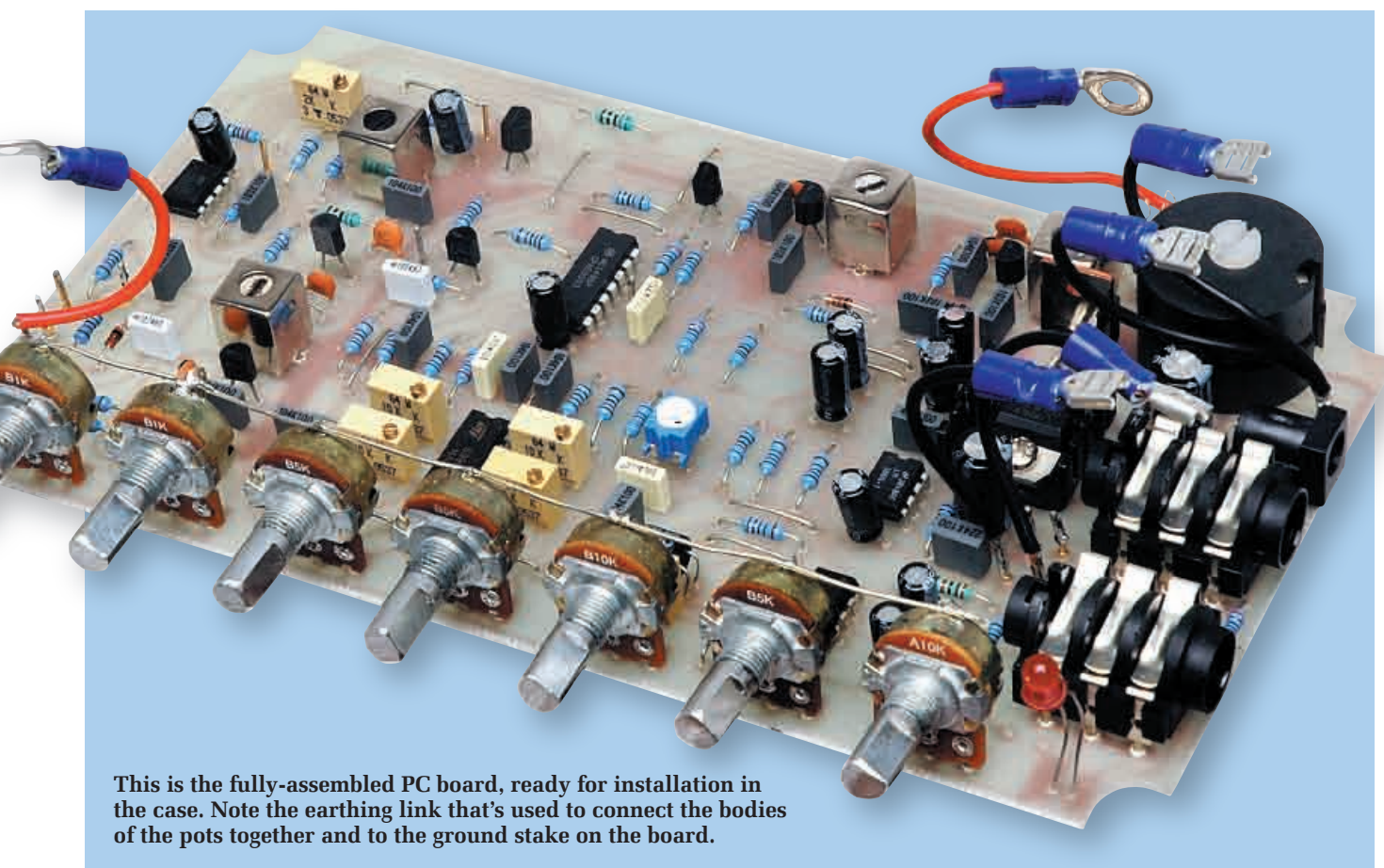
## Potentiometers

Before installing the potentiometers, it's necessary to cut their shafts to length to suit the knobs. On the prototype, this meant cutting the shafts to 11mm. They can be cut using a hacksaw, with the end of the shaft secured in a vice.

Having cut the shafts, break off the locating lug on each potentiometer. The pots can then be soldered in turn to the PC board, taking care to use the correct value at each location.

**The speaker/headphone Volume potentiometer (VR7) at the top of Fig.5 is the only logarithmic type.** It will have an 'A' marking (A = log curve) on its body (eg, 'A10k'). Don't





This is the fully-assembled PC board, ready for installation in the case. Note the earthing link that's used to connect the bodies of the pots together and to the ground stake on the board.

confuse it with the 10k $\Omega$  linear pot used for the Skew control (curve B).

As shown in Fig.5, the pot bodies are all wired together and connected to circuit ground. This is done by soldering a 140mm length of tinned copper wire along the top of the pot bodies and then running a short link back to the GND PC stake.

Note that the anodised coating on each pot body will need to be scraped away at the soldering points.

Earthing the pot bodies helps prevent tuning changes due to capacitance effects when your hand touches the adjusting knobs. The plastic knobs also help to prevent tuning changes, so be sure to only use plastic knobs.

Once the pots are in, LED1 can be installed. Take care with its orientation – its anode (A) lead is the longer of the two). Note that the LED should be mounted at full lead length so that it can later be bent over to pass through its matching hole in the front panel (this hole is in line with the potentiometer shafts).

### Coil winding

The last component to mount on the board is equalising coil L1. It comprises

a bobbin and two core halves, and is wound using 300 turns of 0.25mm enamelled copper wire.

The coil is wound onto the bobbin, after which the two core halves are fitted, along with a 2.5mm nylon spacer. This spacer provides an air gap, which lowers the effective permeability of the core. This lessens any variations in the inductance of the equalising core with respect to temperature.

Winding the coil is straightforward – it's simply a matter of winding on the 300 turns of wire and then twisting the leads together to prevent the coil unwinding. That done, trim these leads to about 20mm and clean the enamel from their ends, so that they are ready to solder to the board.

**Important: equalising coil L1 must be wound so that its self-capacitance is as low as possible. In practice, this means that the windings should be jumble-wound by hand without regard to neatness. Do not wind each layer with each turn neatly placed adjacent to the next.**

The core can now be fitted to the bobbin as follows. First, insert an M4  $\times$  25mm nylon screw through one core

half and install three M4 nylon washers (these effectively form the 2.5mm nylon spacer). That done, install the second core half in position, fit the assembly to the PC board and secure it using an M4 nylon nut – ie, the screw protrudes through the PC board and the nut is placed on the underside.

Finally, solder the two coil leads to their adjacent PC stakes.

### Cutouts and hardware

Your next task is to drill the plastic case as shown in Figs.6 to 8. Basically, this involves drilling the following holes:

- Eight holes in the front side of the case for the pot shafts (7) and the LED
- Holes in the lefthand end and rear side for the antenna brackets
- Holes in the righthand end for the two jack plug sockets, the DC power socket, the two rocker switches and a banana socket
- Holes in the bottom of the case to attach the metal baseplate and a 1/4-inch tee-nut (which is used to attach the stand)

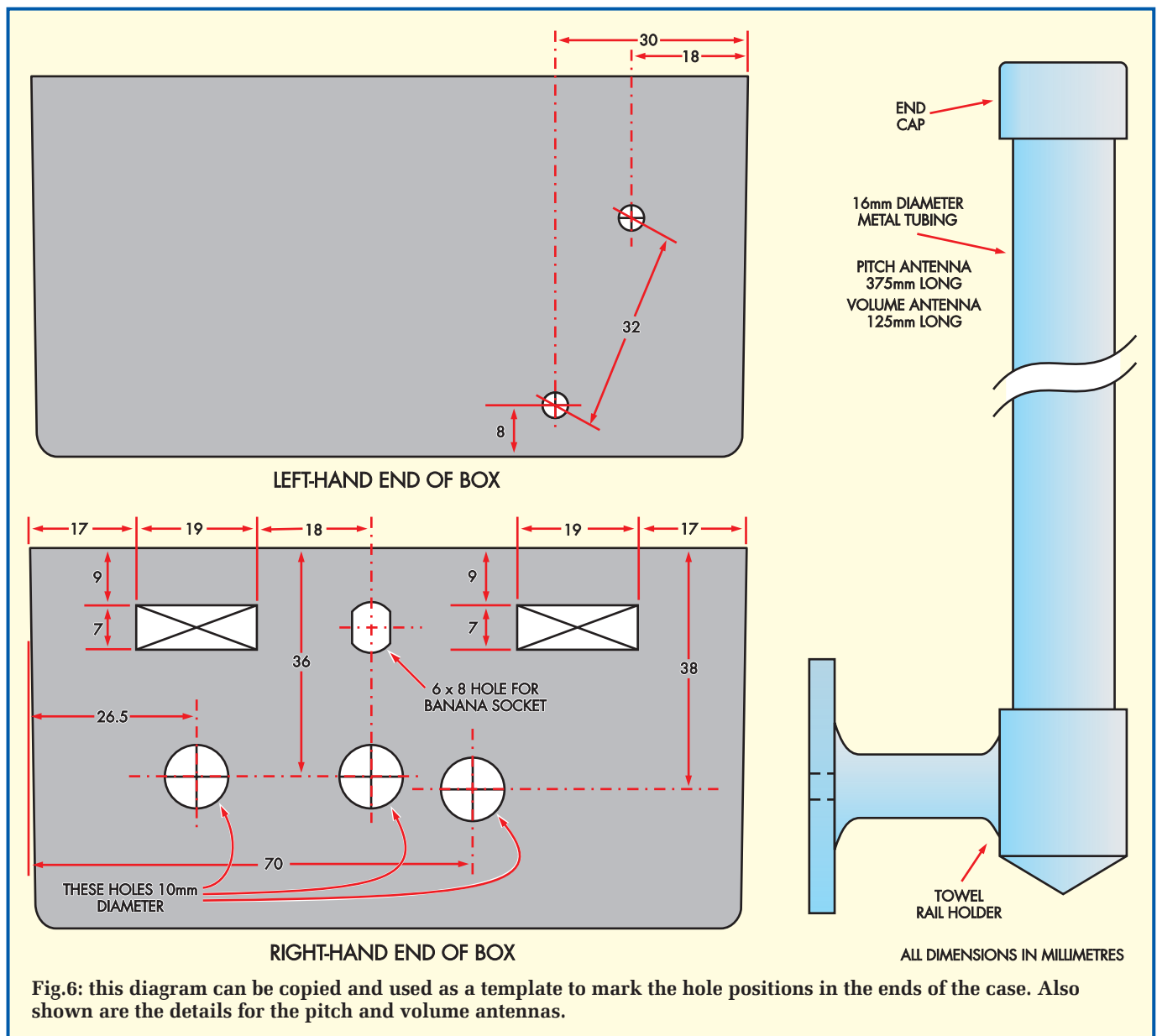


Fig.6: this diagram can be copied and used as a template to mark the hole positions in the ends of the case. Also shown are the details for the pitch and volume antennas.

- Holes in the lid of the case to mount the loudspeaker and to let the sound escape.

Note that the holes for the switches can be made by first drilling a series of three holes for each and then filing them to the required rectangular shape. The banana socket requires an elongated hole and this can be done by first drilling and reaming it to 6mm and then elongating it using a rat-tail file.

As shown in the photo, the metal baseplate is attached to the underside (base) of the case and is secured using M3 x 6mm screws and nuts. The 1/4-inch tee-nut goes in the centre and is glued to the baseplate and box using epoxy adhesive.

Note that an eyelet and short length of green hook-up wire is attached to the front left corner baseplate mounting screw – see Fig.5

Finally, the lid of the case requires four 3mm holes to mount the loudspeaker, plus a pattern of 13 x 6mm holes directly in front of the loudspeaker cone.

## The antennas

The Pitch and Volume antennas are both based on towel-rail end brackets and lengths of 16mm chromed steel tubing (or towel railing) – see Fig.6. The pitch antenna is cut to 375mm long, while the volume antenna is 125mm long. Plastic end caps are used to cover the exposed ends of each antenna,

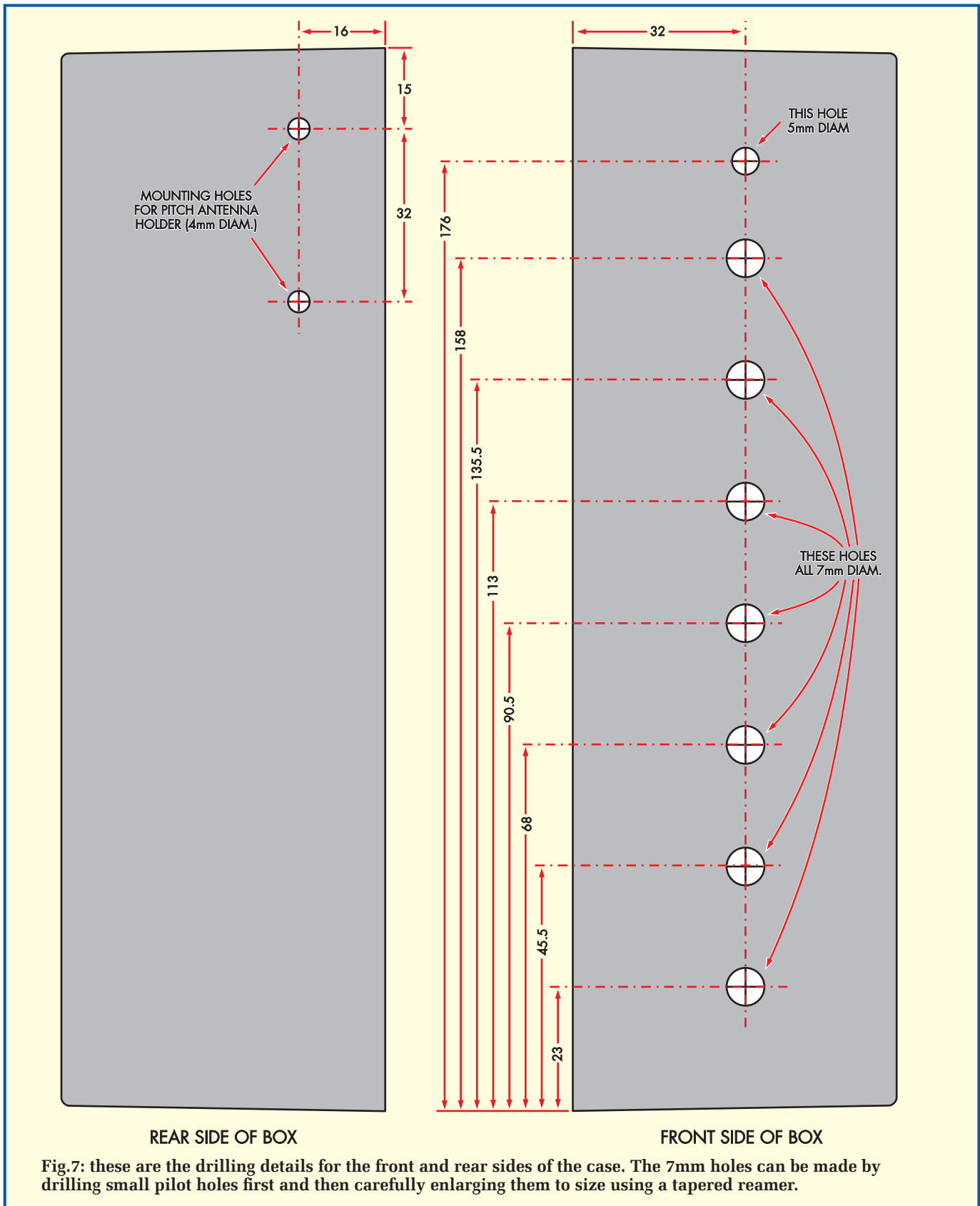
while the opposite ends fit into the end brackets, which in turn are attached to the case using M4 x 10mm screws and M4 nuts.

## Final assembly

Now we come to the final assembly. The PC board simply clips into the integral slots inside the case, but before doing this, it's necessary to first remove the top screw that's used to secure the mounting bracket for the volume antenna. In addition, it will be necessary to remove some of the ribbing inside the box adjacent to the DC socket and around three of the potentiometers, so that they sit flat against the sides of the case.

You can quickly determine what has to be removed by trial fitting the board





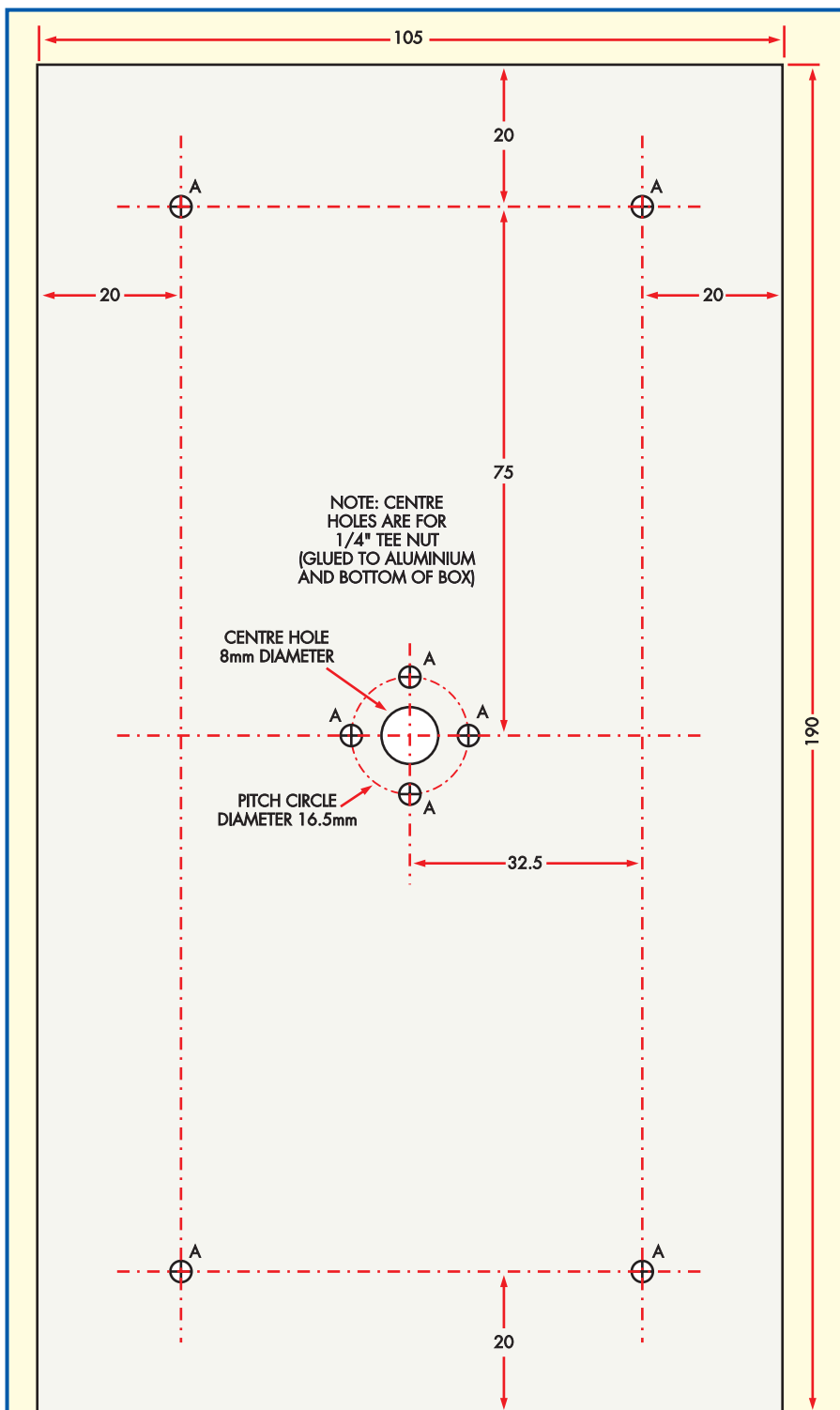
inside the case. A sharp chisel can then be used to remove the ribbing.

Next, solder the green earth wire from the groundplane to the GND stake

on the underside of the PC board (ie, to the same stake that earths the pot bodies). A second 150mm-long green earth wire should then be soldered to the

**GND stake on the top of the PC board for later connection to the banana socket. Don't do this after the PC board is in the case, as heat introduced into**

## Constructional Project



BASE PLATE – CUT FROM 1mm THICK ALUMINIUM

HOLES A ARE ALL 3mm IN DIAMETER

ALL DIMENSIONS IN MILLIMETRES

Fig.8: here's how to drill the bottom of the case and the aluminium base plate. Make sure that the holes for the tee-nut are accurately positioned.

Right: the threaded tee-nut is pushed through its holes in the baseplate and secured in position using epoxy adhesive. It accepts the threaded tip of the microphone desk stand.



the GND stake could melt the soldered joint for the groundplane lead without you knowing.

You can now fit the washers to the pot shafts and insert the PC board into the box. This is done by angling it so that the pot shafts enter the holes in the side of the box, after which the board can be clipped into the integral side mouldings.

Once it's in, secure each pot with its nut and fit the two jack socket nuts. The leads on the LED can then be bent down by 90° so that it goes through its matching hole in the front panel.

All that remains now is to fit the two switches and the banana socket and complete the external wiring. Note that the connections to both the volume and pitch antenna brackets are made via crimp-connection eyelets, which are secured under the nuts of the mounting screws. **Initially, the pitch antenna wire should be connected directly to the PC stake marked with an 'X' (adjacent to T2), to bypass the equalising coil (L1).** It's later connected to its correct PC stake after the setting-up procedure has been completed (more on this later).

The connections to the two switches can either be soldered or made via spade connectors. The final wiring connections are to the loudspeaker and to the banana socket from the GND stake.

### Initial checks

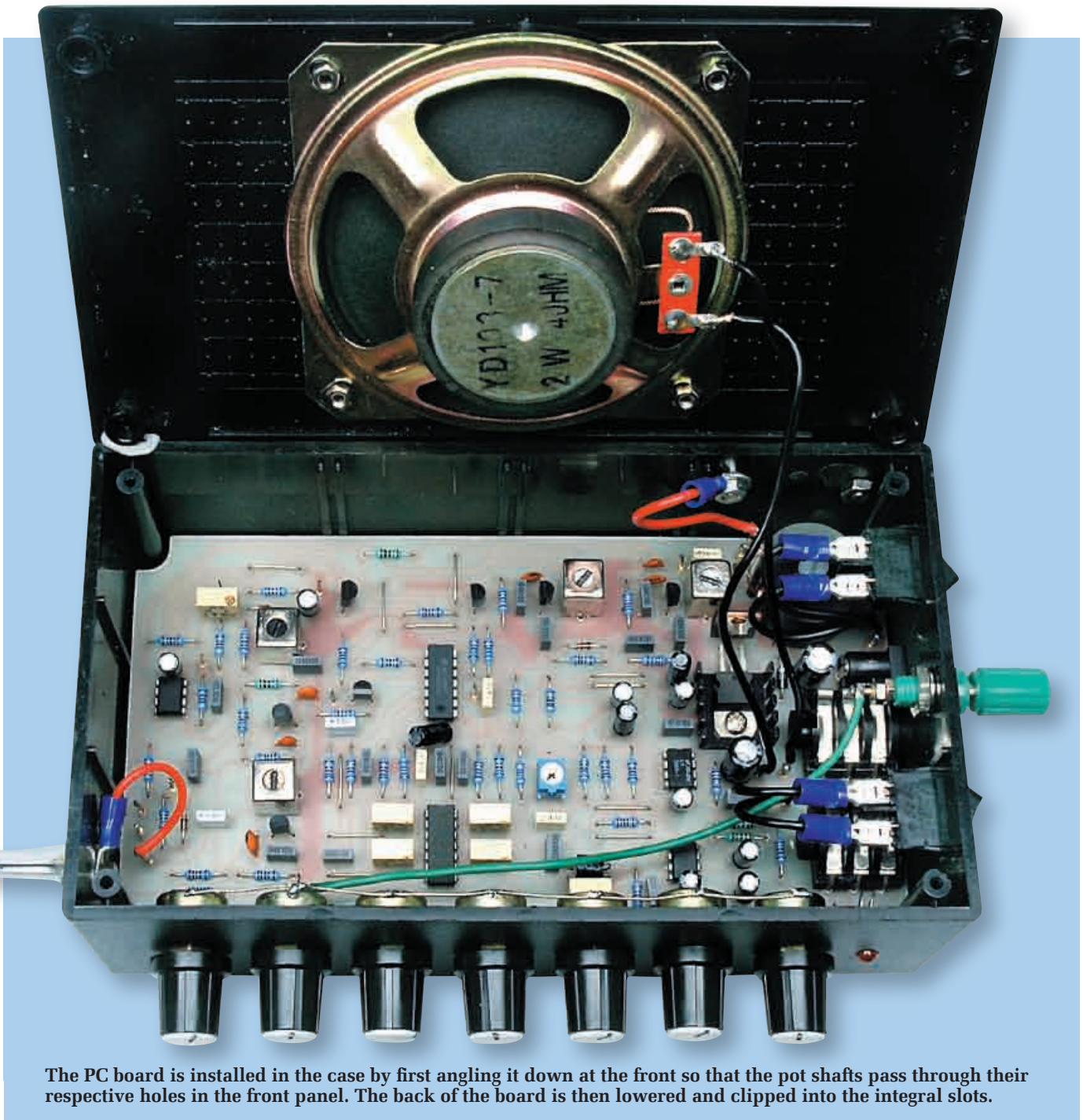
Now for the initial set-up procedure. Here's what to do, step-by-step:

**Step 1:** set trimpots VR9 and VR10 fully clockwise, VR8 and VR11 fully anti-clockwise, VR12 fully anticlockwise and pots VR1 to VR7 to mid-position. If necessary, now is also a good time to remove the indicator buttons from the knobs and replace them so that the pointers are vertical.

**Step 2:** check that the power LED lights when power is applied. If it doesn't light, check the polarity of the DC plug from the plugpack. The centre pin should be the positive. If this is correct, then the LED might be installed the wrong way around.

**Step 3:** check the supply rails to the ICs. IC2 should have 9V between pins 4 and 11, IC3 should have 9V between pins 4 and 7, IC4 should have 9V between pins 4 and 6, and IC5 should have 9V between pins 4 and 8.





The PC board is installed in the case by first angling it down at the front so that the pot shafts pass through their respective holes in the front panel. The back of the board is then lowered and clipped into the integral slots.

**Step 4:** connect a multimeter between test points TP3 and TP GND. Apply power and adjust transformer T4 for a reading of about 1.5V.

**Step 5:** connect the multimeter to TP4 and adjust VR14 for a reading of about 7V, regardless of hand movement near the volume antenna.

**Step 6:** check each oscillator for correct operation by measuring the DC voltages on the drains of JFETs Q1, Q3 and Q5. These should each measure between 3V and 6V.

**Step 7:** check the voltages on the remaining JFETs and transistors. Q2 and Q4 should have around 0.3-0.4V on their source (middle) pins; Q6 should have about 1.4V on its base (middle pin); and Q7 should have about 7V on its emitter (E).

**Step 8:** vary VR3 and check that the voltage at TP1 ranges from about 0.7V to 7V. Similarly, varying VR4 should vary the voltage on TP2 over the same range.

**Step 9:** set VR2 to its centre position and adjust the slug in T2 until a low-

frequency sound is produced from the loudspeaker. Check that the pitch of this sound changes in response to hand movement near the pitch antenna. This should start off at a very low frequency with the hand away from the antenna and rise in frequency as the hand is brought nearer to the antenna.

**Step 10:** attach the microphone desk stand to the unit and readjust transformer T2 carefully until the results are correct. Check that VR2 alters the tuning frequency.



The microphone desk stand screws into the tee-nut that's attached to the underside of the case.

### Equalising coil

If this is all working, it is time to tune the unit with the equalising coil connected. Here's the step-by-step procedure:

**Step 1:** set pot VR2 (Pitch Range) to its mid-position.

**Step 2:** wire up the test circuit as shown in Fig.9 using insulated wire. **Note that the equalising coil lead must be lifted from point X and connected to the far left side of the board via a length of hook-up wire instead. Note also that the pitch antenna lead is moved to its correct location.**

**Step 3:** turn T2 slowly and find the point where the voltage is lowest. In the prototype, the voltage dropped from over 2V down to around 0.4V at the dip. The idea of this test is to find the frequency where the antenna and equalising coil resonate, as indicated by a dip in voltage as T2 is adjusted.

**Step 4:** move your hand so that it is about 10cm away from the antenna. The voltage dip should change by about 50mV. By contrast, if you incorrectly set T2 at a position away from the dip setting, the measured voltage will vary by more than 200mV on this test.

**Step 5:** verify this dip in voltage by placing the lid on the box (as this affects the reading) and placing your hand about 10cm away from the antenna. Now remove the lid, adjust T2 slightly, replace the lid and repeat the previous step (Step 4). **Note: the Therm-in must be away from metal objects or the results will be affected.**

**Step 6:** repeat step 5 several more times, adjusting T2 just a little each time (don't forget to replace the lid after each adjustment).

If the slug inside T2 has to be set at the top or bottom of its range to give the required voltage dip, you will need to change the number of turns on equalising coil L1. Add a turn or two if the slug is at the top of its range, and take off a turn or two if the slug is at the bottom of its range. If you cannot find the dip, check that the antenna has the same length and diameter as used in our prototype.

The gap between L1's cores also affects the resonance. A slightly smaller gap will give a lower resonant frequency and a wider gap will raise the resonant frequency.

When you are satisfied that the resonance adjustment is correct, do not make any further adjustments to T2's setting.

**Step 7:** connect the equalising coil back into circuit by reconnecting it to point X, as shown on the board overlay diagram (Fig.5). The two insulated wiring leads (shown green and orange on Fig.9) should also now be removed.

**Step 8:** adjust T1 until the tone is at a low frequency, then put the lid on. If necessary, readjust T1 so the tone starts off at a very low frequency and increases as the hand is brought closer to the pitch antenna.

Frequency changes with hand movement should now be quite linear for each octave up to 2048Hz. Note that if

the antenna gives very strange results or the frequency does not appear to change, the resonance setting for the equalising coil is probably incorrect. In that case, adjust T2's slug slightly anticlockwise and readjust T1 until the effect disappears.

### Volume adjustment

One problem that you may have at this stage is heterodyning (ie, an audible squeal) in the audio output. This effect is an audible beat frequency which is produced by frequency differences between the volume oscillator and the pitch and reference oscillators.

The solution to this problem is to adjust transformer T3 until the whistle disappears. Note that changing T3 may affect the voltage at TP4. If this drops below 6V, you may not hear anything at all, and so T4 will need readjusting to bring TP4's voltage back above 7V. Check again for spurious noises in the sound.

Now connect your multimeter between TP3 and TP GND and adjust T4 so that the voltage falls as your hand approaches the volume antenna. Set T4 so that the voltage on TP3 is around 1.6V.

Note that if you set T4 so TP3 is at 1.3V instead, then the volume control range with hand movement will be less. This will cause the volume control to be more abrupt. Conversely, setting it at more than 1.6V will widen the control range with hand movement, so there will be a more gradual volume control.

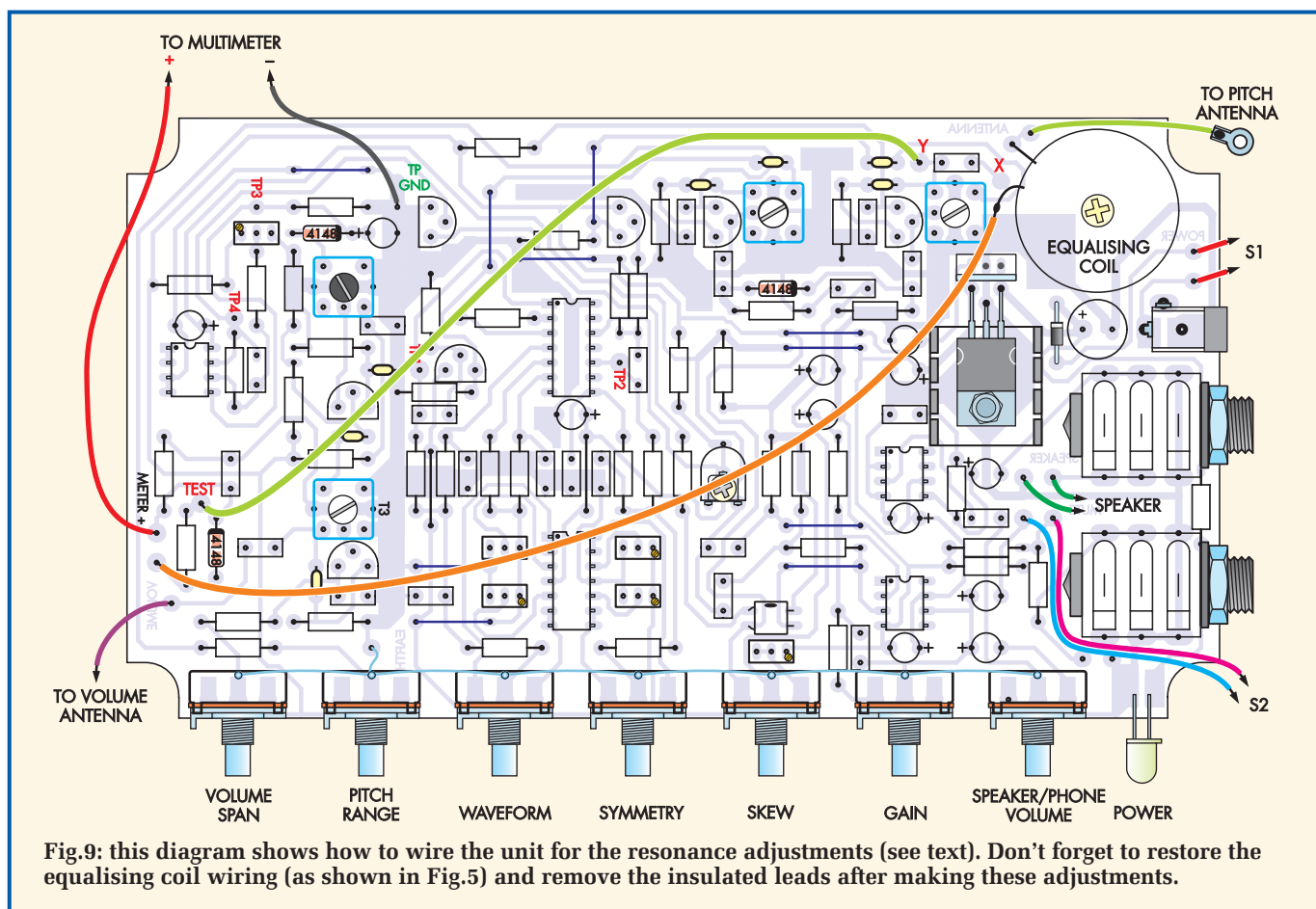
Next, make sure that VR1 is set to its mid position, then set VR14 so that TP4 is at 6V when your hand is away from the volume antenna. That done, adjust VR1 so that the volume control range is nice and smooth.

### Waveform adjustments

The waveform adjustment range is made by first setting VR3 fully anticlockwise and adjusting trimpot VR9 so that the reading at TP1 is 0.7V. Once that's been done, set VR3 fully clockwise and adjust VR8 for 1.5V at TP1.

The symmetry range adjustment uses a similar procedure. First, set VR4 fully anticlockwise and adjust VR11 for 6.9V on TP2, then set VR4 fully clockwise and adjust VR10 for 0.9V on TP2. You can experiment with these ranges, but be aware that with wider adjustment settings, the signal





can drop out for particular settings of VR3 and VR4.

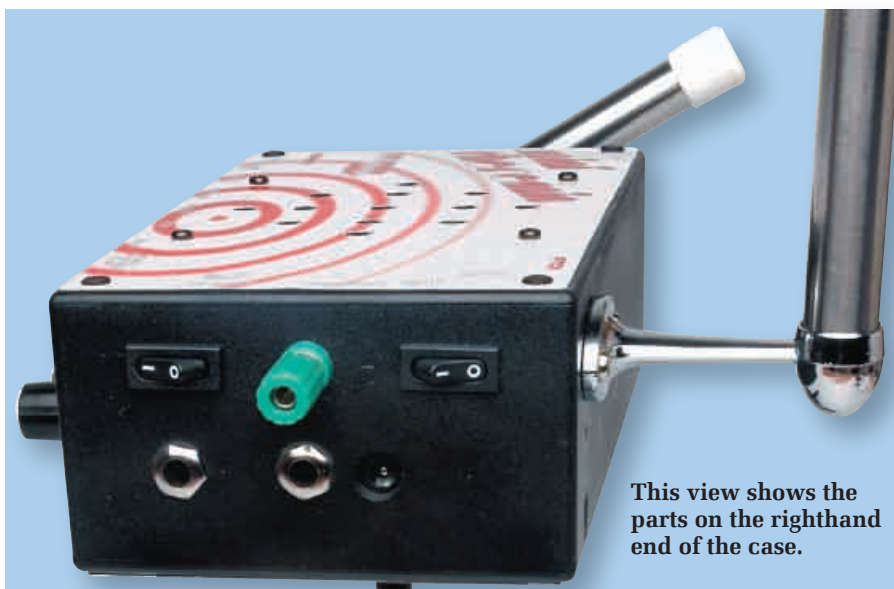
## Skew range

The Skew range is adjusted using VR12. This increasingly limits the skew range as it is turned clockwise and vice versa.

You may wish to limit the skew range for several reasons. First, you will find that with too much skew control, the lowest frequency that can be played will be too high. This is because the pitch and reference oscillators lock together at high skew settings. The oscillators will only snap to a different frequency when sufficiently pulled by a large change in hand movement adjacent to the pitch antenna.

Second, once a certain skew level is reached, further increasing the skew does not necessarily change the tone. Finally, too much skew will pull the reference and pitch oscillators so far off frequency that the pitch adjustment control will no longer be able to set the lowest frequency required.

Adjustment of VR12 should be done with these points in mind.



## Earthing

Finally, note that the Theremin will work best if the circuit earth connects to either mains earth or to your body.

A mains earth connection is automatically made if the Theremin is connected to an earthed amplifier. However, if the Theremin is not earthed in this way, an earth strap can be used

to connect between your lefthand wrist and the banana socket on the Theremin. Alternatively, you could also run the Theremin from a 12V supply that has an option to connect the 0V rail to mains earth.

**EPE**

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# Monopoly Money

by Dave Geary



Waddingtons have filled many an evening with the ever popular Monopoly. This game of avarice by stealth (or is it chance?) has been with most of us since childhood. One of the reasons we play it less than we might is probably the time taken to set it up, and the time taken handling cash.

**T**HIS project reduces the set up time and improves the accuracy – or should I say fairness – of the game of Monopoly, as well as providing an ideal opportunity for a little ‘PICing’.

### Serial money laundering

The rules say that one player acts as Banker. It seems logical that in Monopoly, as in life, all the money is controlled by a bank, which cannot run out of cash. Everyone else receives an increasing bank balance in place of hard currency, and for one player to move money to another simply requires a subtract from one, and an add to another of the same amount.

In Monopoly, players only ever pay money (if the banker is considered to be a player). Hence we only need a means for each player to:

- Know their bank balance
- Transfer some or all of that balance to another player
- Be prohibited from becoming overdrawn

- Have some confidence in the Banking system and that no-one is cheating

- Be alerted if another player, including the bank, runs out of cash!

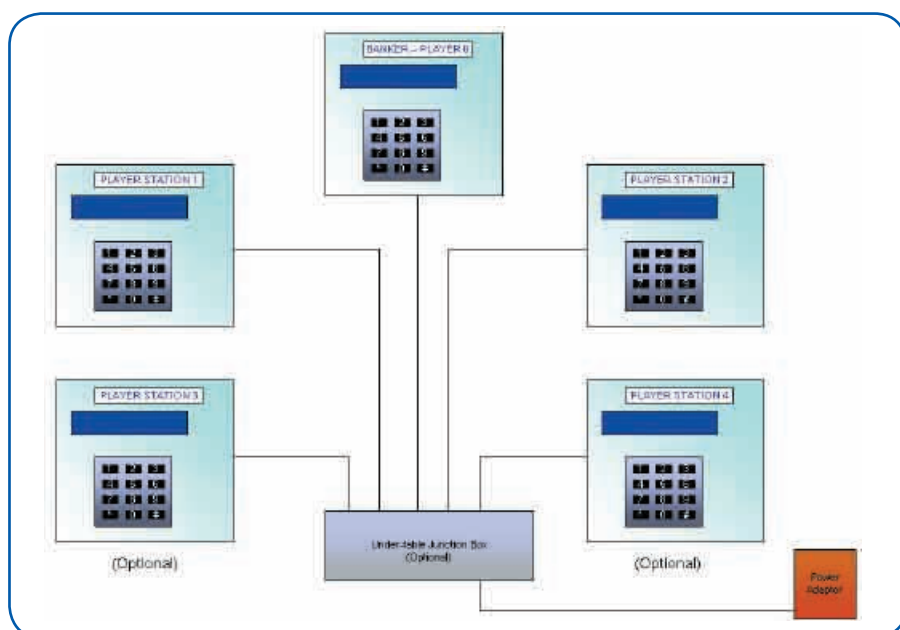


Fig.1: System block diagram layout, including the optional interconnection junction box



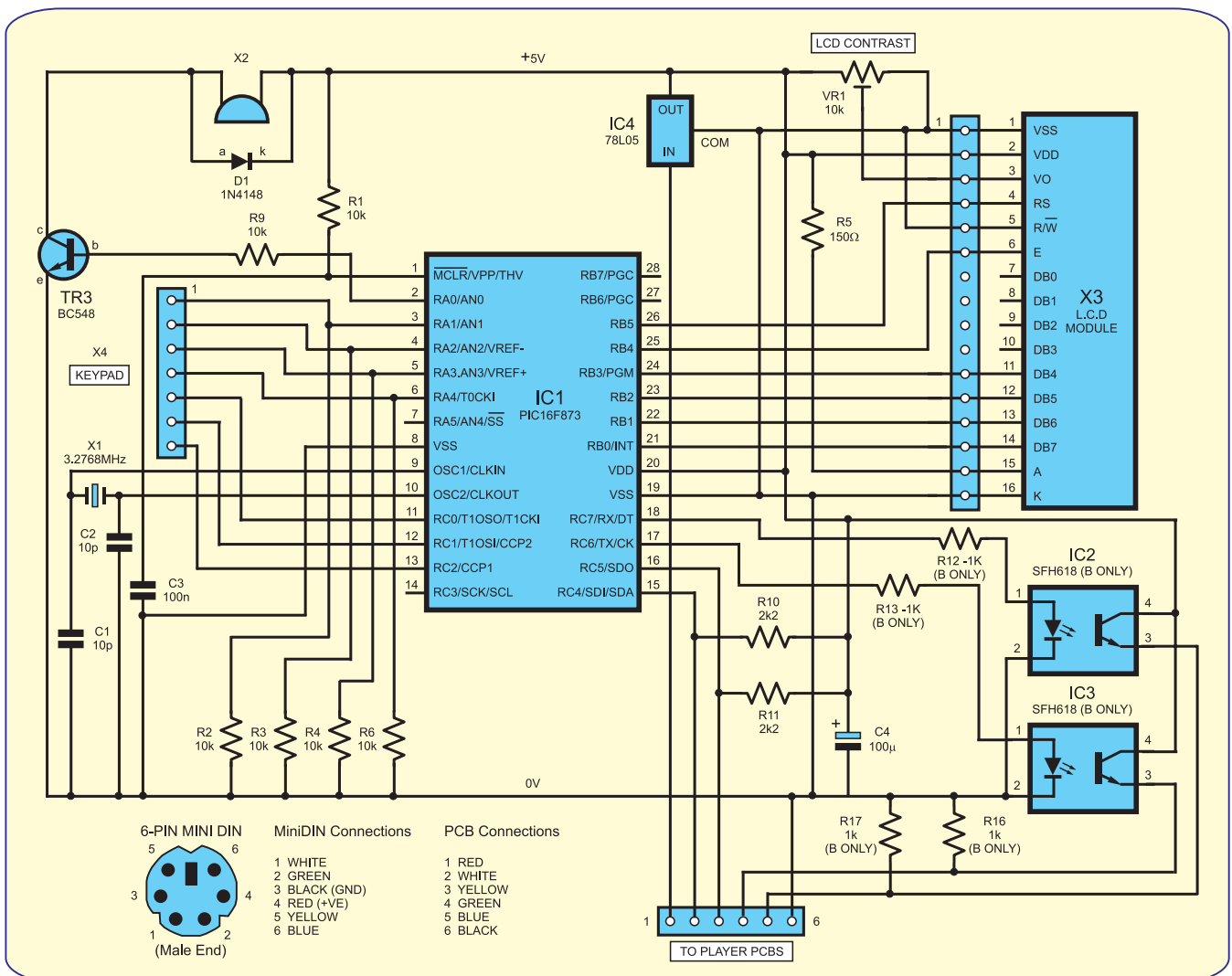


Fig.2: Complete circuit diagram for the Banker station

This project uses up to four Player 'stations' and a Banker 'station'. All use the same PCB (albeit the Banker has different components and software), a low cost LCD display and keypad. Wiring is minimal, using plug-in methods and even the 'play station' cases can be homemade.

The banker holds all the account balances, including its own, which are transmitted around the player stations in turn. This causes the player stations to respond back with any transactions keyed by players.

The minimum number of players is, of course, two plus the banker. The players stations are linked to the banker using six-core PS2 cables, which are freely available from many computer retailers or, of course, eBay.

The six cores are clock and data in each direction, plus power. The system layout, with the option of an 'under-table junction box' and optional players 3 and 4, is shown in Fig.1.

## Cash point

To make life a little easier when playing, it was felt that having all the cables from each player on the table so that they could plug into the Banker would be a nuisance, so a separate 'junction box' was constructed with five six-pin miniature DIN connectors connected in parallel. This also provides an opportunity to connect a power adaptor to the whole network in a neat way.

The system layout drawing shows four player stations, of which you only need two as a minimum, and the banker; it also shows the junction box referred to above, which can sit under the table for convenience, and a power adaptor which most easily powers the system via this junction box. Of course, if you don't want a junction box, you can fit sufficient sockets on various player stations and the banker to connect everything together.

## Bank job

The circuit diagram for both Player and Banker are very similar (see Figs 2 and 3), and there is one common PCB for both. Some components are inserted or omitted depending on whether a player or banker unit is being built, and there is different firmware for each. For the sake of clarity, a circuit diagram for each is shown, rather than combining them into one.

The left-hand side of the circuit is very simple and common to both. A PIC 16F873 was chosen, merely because it had enough ports and was available fairly cheaply. The clock frequency is not too critical and ceramic resonators were chosen from Futurlec, together with the LCD displays. My preference is blue, but there is no reason not to use a more standard green display, which is slightly cheaper.

Resistor R1 and capacitor C3 provide power on reset, and R2, R3, R4

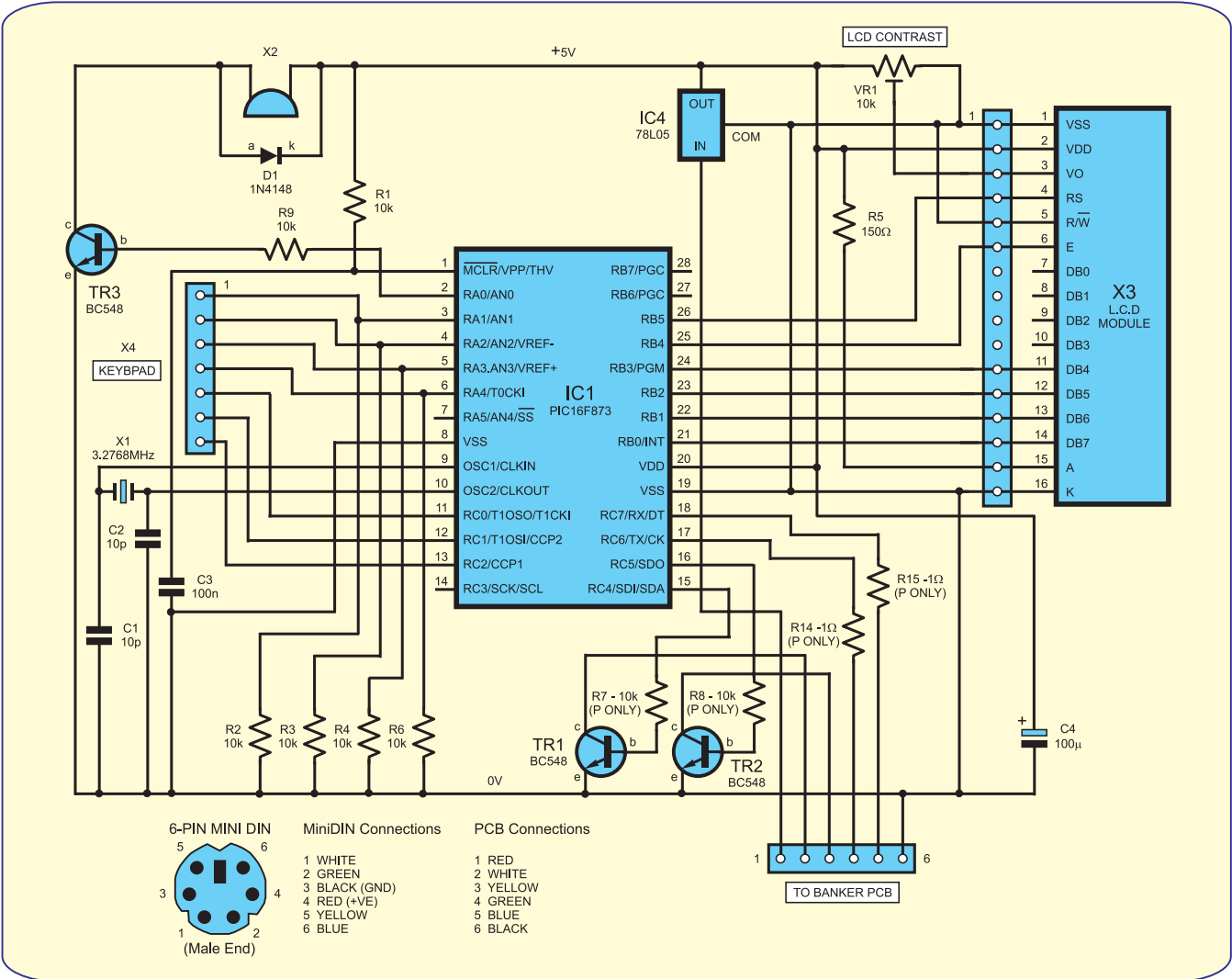
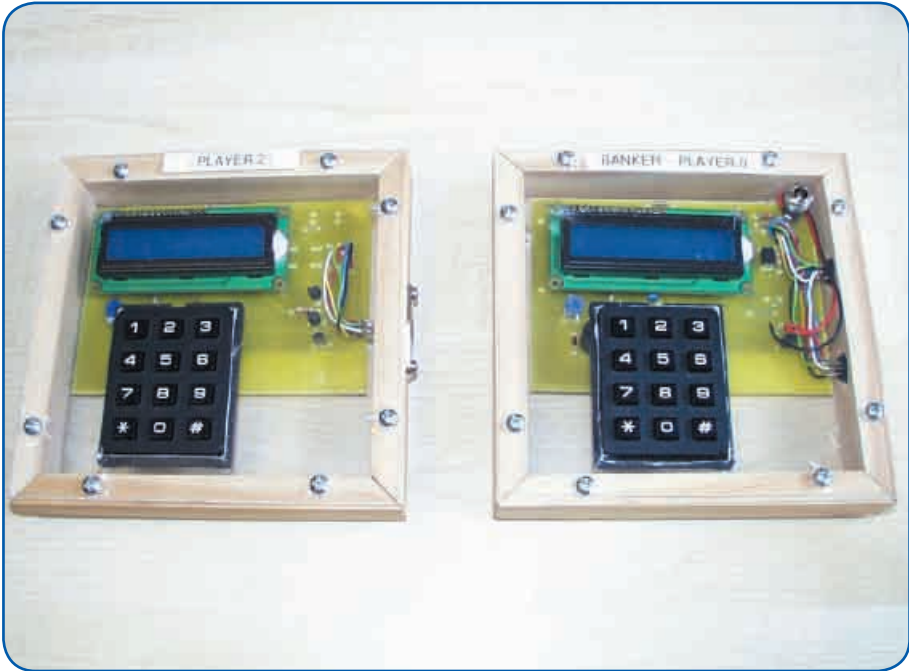


Fig.3: Full circuit diagram for one Player station. You can have up to four players

and R6 are pull-down resistors for the keypad. The other three lines to the keypad are driven high in turn to read the keypad matrix. The buzzer, X2, is driven by transistor TR3 and has a back-EMF protection diode D1, although with the small buzzers specified this could be omitted. However, space remains on the board for those who wish to use a sounder with flying leads to the right of the keypad connector, to the left of IC4.

Also common to both circuits is voltage regulator IC4; regulation is provided on every PCB, so that any voltage drop along the PS2 cables and the six-pin mini-DIN connectors is not an issue. Capacitor C4 provides additional smoothing and resistor R5 provides backlight current limiting; it can be omitted if you use an LCD without a backlight. Potentiometer VR1 will be required to set the display contrast and is accessible from above with the LCD display in place if using the PCB.



Prototype Player and Banker stations showing positioning of the keypads and the 16-character 2-line LCD modules. The DIN sockets are mounted on the sides



On the Banker circuit, resistors R10 and R11 pull up the data inputs to the PIC. The player stations pull these lines low to transmit data, which is an easy way of implementing a ‘many-to-one’ topology. I adopted a slightly more novel approach for transmitting data to the players, with R16 and R17 acting as pull-down resistors, with lines pulled up by optoisolators IC2 and IC3.

The reason for this choice, as opposed to using a conventional transistor stage, is that I have experienced some problems using serial interfaces over PS2 cables in the past. This method works well in practice, even when driving multiple PS2 cables, two metres long, and in parallel.

Resistors R12 and R13 limit current through the LEDs in the optoisolators.

On the Player circuit diagram (Fig. 3), R14 and R15 are shown as one ohm resistors, but can be replaced with wire links. Transistors TR1 and TR2 act as ‘pull-down’ transistors to transmit data back to the banker.

Serial killer

A protocol for serial communication was developed with a similar principle for data both from and to the banker. Data from the banker module is sent to every player station and therefore each batch of data has to contain the destination player station ID. Each player therefore waits to receive data with its station ID included before processing it, after which, any transaction which a player keys is sent back to the banker. The process is shown in Fig.4.

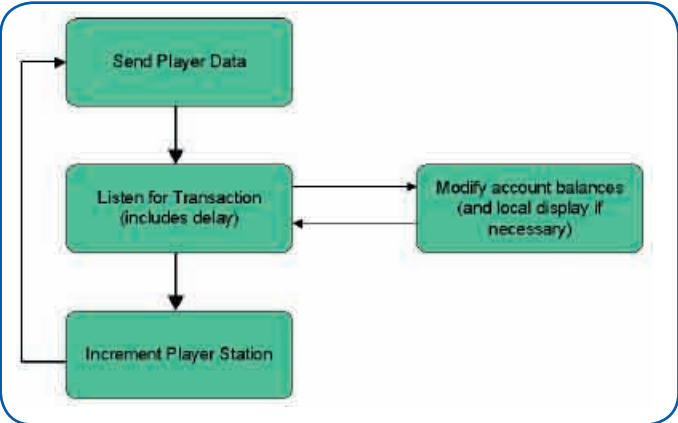


Fig.4: Block diagram showing the transaction process

Parts List – EPE Monopoly Money

Banker – one required

- 1 PC board, code 671, available from the EPE PCB Service, size 116mm x 82mm
- 1 16 x 2 line LCD module, as Futurelec BLUELCD16 x 2BL (X3)
- 1 3.2768MHz or 3.58MHz crystal or ceramic resonator (X1)
- 1 12-key keypad, as Futurelec KEYPADSM (X4)
- 1 Sounder, PCB mounting (X2)
- 1 Female header strip, 40-way for LCD and keypad connection
- 1 DC power adaptor 9V, 100mA minimum
- 1 Power connector to suit the DC power adaptor
- 1 Enclosure – see text
- 1 28-pin narrow DIP socket
- 1 6-pin mini-DIN connectors – see text for quantity required

- 1 6-pin mini-DIN male-to-male leads one per player

Semiconductors

- 1 BC548 NPN transistor (TR3)
- 1 PIC16F873 preprogrammed microcontroller (Banker IC1)
- 2 SFH618 optoisolators (IC2, IC3)
- 1 78L05 voltage regulator (IC4)

Capacitors

- 2 10pF ceramic (C1, C2)
- 1 100nF ceramic (C3)
- 1 100µF 10V electrolytic (C4)

Resistors (0.25W, 1% carbon film)

- 6 10kΩ (R1, 2, 3, 4, 6, 9)
- 1 150Ω (R5)
- 2 2.2kΩ (R10, R11)
- 4 1kΩ (R12, 13, 16, 17)
- 1 10kΩ cermet trimpot, horiz (VR1)

Note: R7, 8, 14 and 15 are not required for the Banker PCB.

Data Format – Banker to Player

Header 1	Header 2	PS I.D.	Balance H	Balance L	LastID	LastTrH	LastTrL
11111111	00011100	000000(ID)	xxxxxxx	xxxxxxx	000000(ID)	xxxxxxx	xxxxxxx
[Start Bytes to align data-]		Address of Player to whom data is addressed	[Player Bank Balance-]		Last Player ID to receive money	[Amount of last transaction-]	

Data Format – Player to Banker (sent after the Player has received valid data as above)

Header 3	Header 4	SMPC	Balance H	Balance L	NewID
11111111	00011100	000000(ID)	xxxxxxx	xxxxxxx	000000(ID)
[Start Bytes to align data-]		Address of Player sending money	[Player Bank Balance-]		Address of Player receiving money

Fig.5: The format for sending data from the banker to the player station is a series of 8-bit bytes



# Constructional Project

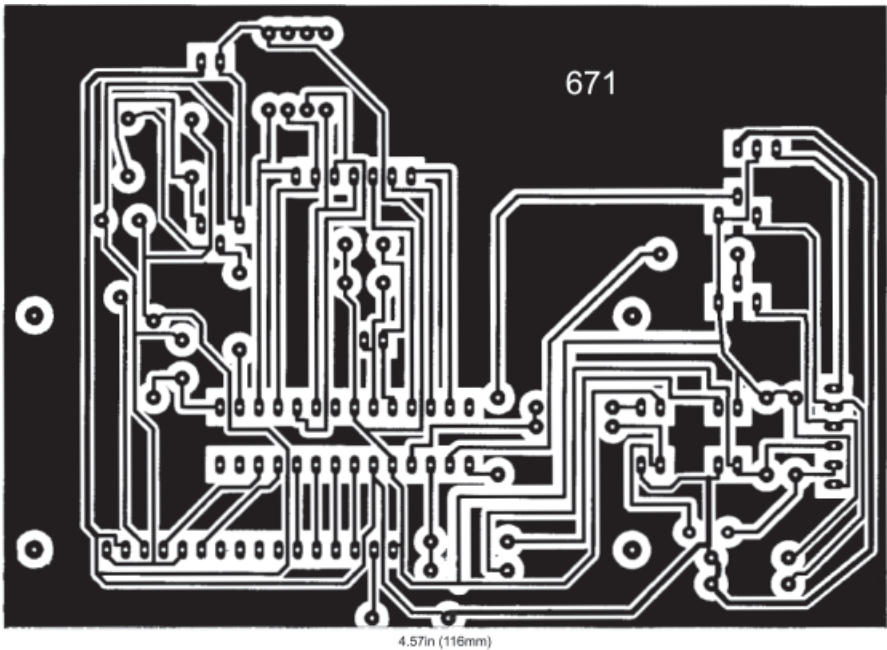
The format of the data from banker to player station is a series of 8-bit bytes as shown in Fig. 5. The transaction results in one account being decremented by the amount of the transaction, and another incremented.

The player station software prevents any transaction value above the players bank balance, and, similarly (and unlike real life, perhaps?) the banker is prevented from transferring money above its own reserve. In the event of either of these, the LCD Display will show \* OVERDRAWN! \* and the buzzer will sound embarrassingly!

Note that the Banker has a Player ID of 0; the others are all 1,2,3, or 4, which is set on first switch on. In each Player unit, the station ID is set using the keypad and stored in EPROM, and becomes enabled after the next power up (preventing anyone cheating by emulating another player). Each player therefore has the same software, which is then configured after construction.

## Construction

There is only one PCB design for this project, shown in Fig. 6. The different circuits are accommodated by the inclusion or exclusion of components. This board is available from the *EPE PCB Service*, code 671.



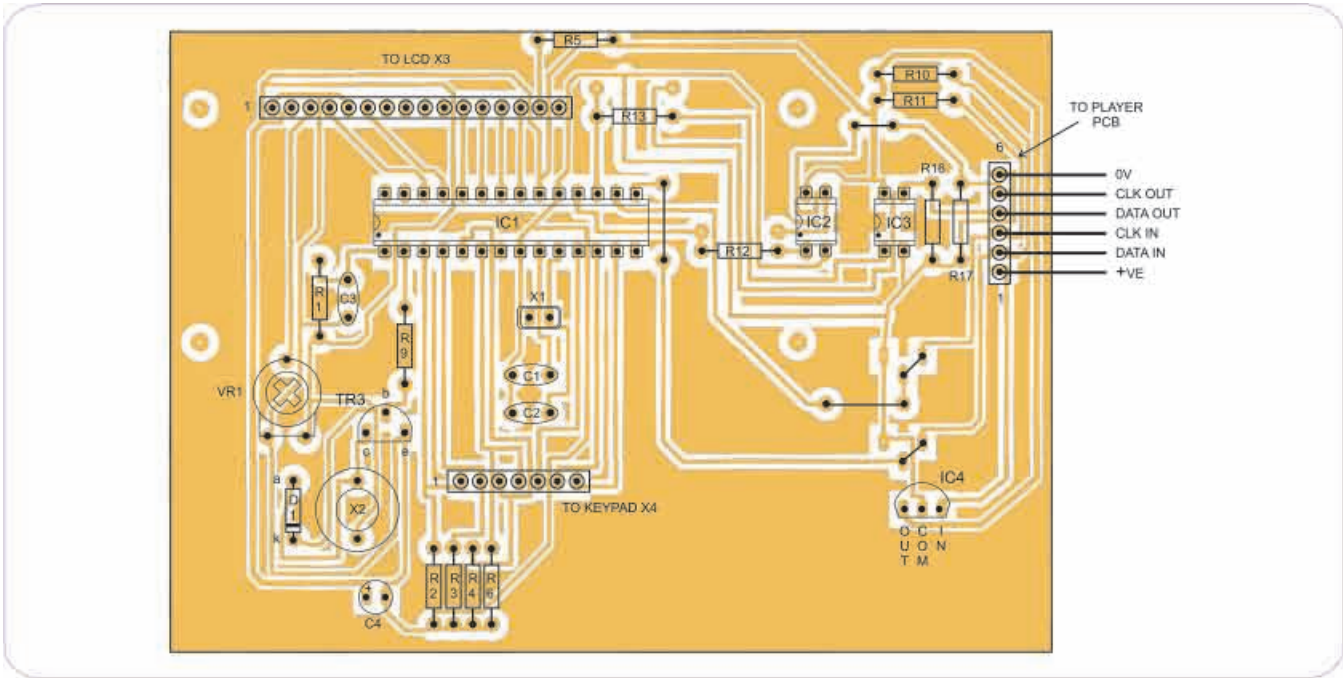
**Fig.6:** Full-size printed circuit board copper foil master pattern. This board is used both for the Banker and Player stations

The specified display and keypad will plug directly into the PCB so that the only wiring is from the PCB to the 6-pin mini-DIN socket.

If using the PCB layout, construction is simple, just by following the appropriate overlay. Build just one Banker as Fig.7, plus 2, 3, or 4 players as Fig.8, as needed. The PCB connectors were also purchased from Futurlec. There is a choice of using

a ceramic resonator or a crystal (X1), either of which can lie flat on the PCB as there is plenty of room.

Begin assembly by inserting any wire links, then the resistors, capacitors, IC socket, transistors and regulator, followed by the PCB connectors. Solder a pin strip to the LCD display, which can then plug directly into the PCB connector. The contrast trimmer VR1 can be adjusted with the display in position.



**Fig.7:** Banker circuit board component layout. The LCD display module and keypad plug directly into the on-board pin-header strips



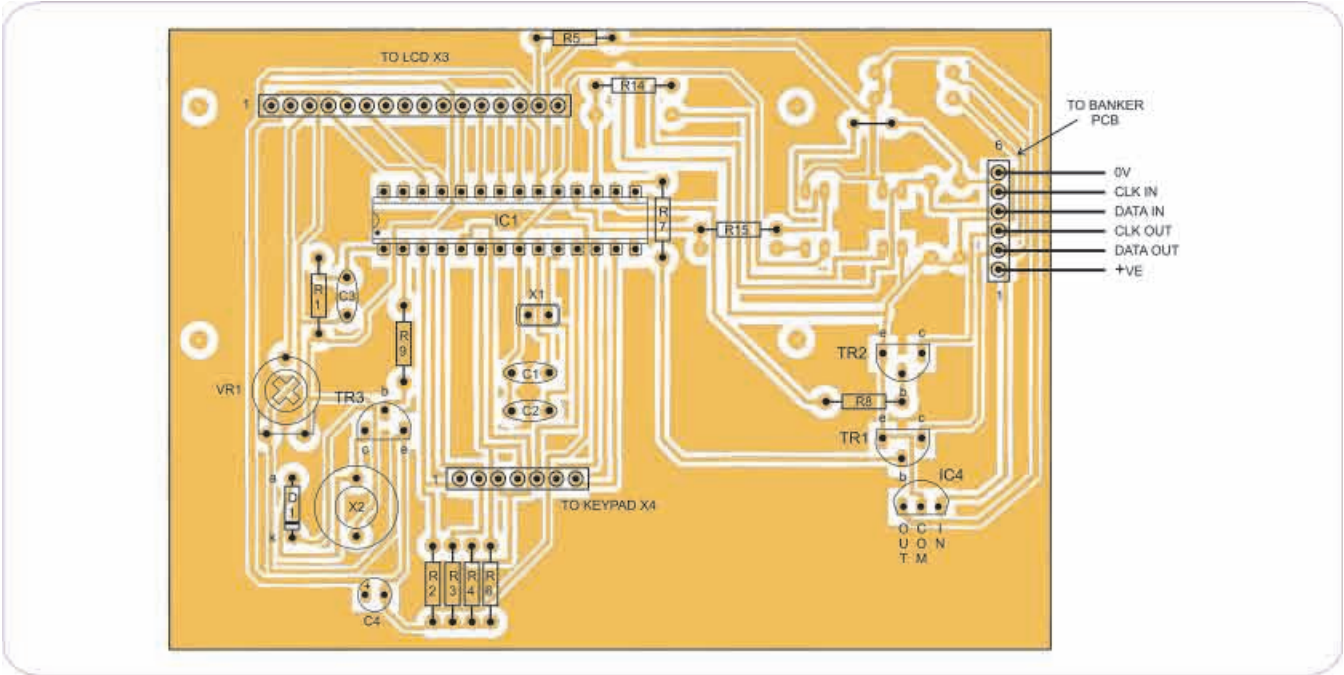


Fig.8 (above): One Player (repeat for other players) circuit board component layout

One difficulty was finding a suitable case. In the end, a simply constructed wood and plastic case was manufactured from 21mm x 12mm batten and secondary glazing material, see Fig. 9. The PCB is a tight squeeze, do not do the screws up too tight!

The keypad will, of course, need a cutout which is best located by trial, and made using a small low-voltage DIY 'hobby' drill, such as a Dremel. Drill a 3mm diameter hole in each corner of the keypad cutout, and then use a cutting wheel to cut straight lines between each hole. The dimensions shown are for the specified keypad.

Fig.9 (left): General guide and case dimensions for both the Banker and Player units

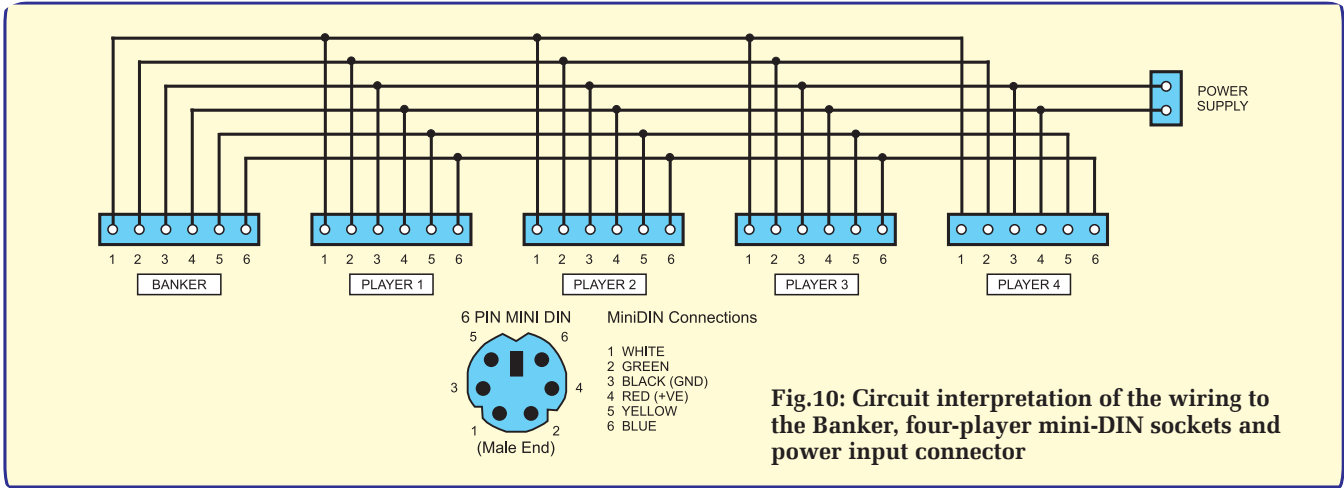
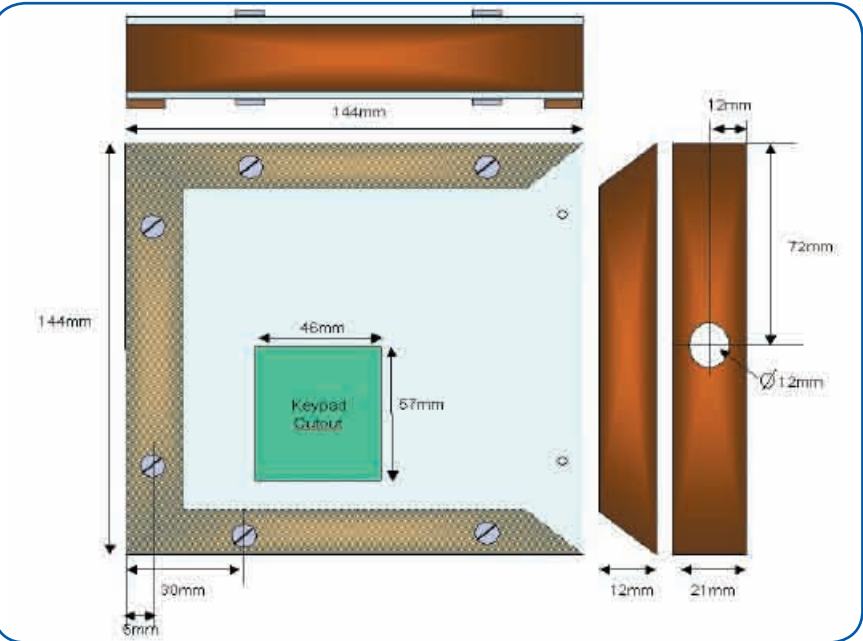


Fig.10: Circuit interpretation of the wiring to the Banker, four-player mini-DIN sockets and power input connector

Parts List – EPE Monopoly Money

Player – two to four required

- 1 PC board, code 671, available from the EPE PCB Service, size 116mm x 82mm
- 1 16 x 2 line LCD module, as Futurelec BLUELCD16 x 2BL (X3)
- 1 3.2768MHz or 3.58MHz crystal or ceramic resonator (X1)
- 1 12-key keypad, as Futurelec KEYPADSM (X4)
- 1 Sounder, PCB mounting (X2)
- 1 Female header strip, 40-way for LCD and keypad connection
- 1 DC power adaptor 9V, 100mA minimum
- 1 Power connector to suit the DC power adaptor
- 1 Enclosure – see text
- 1 28-pin narrow DIP socket
- 1 6-pin mini-DIN connectors – see text for quantity required
- 1 6-pin mini-DIN male leads one per player

Semiconductors

- 3 BC548 NPN transistors (TR1-TR3)
- 1 PIC16F873 preprogrammed microcontroller (Player IC1)
- 1 78L05 voltage regulator (IC4)

Capacitors

- 2 10pF ceramic (C1, C2)
- 1 100nF ceramic (C3)
- 1 100µF 10V electrolytic (C4)

Resistors (0.25W, 1% carbon film)

- 8 10kΩ (R1, 2, 3, 4, 6, 7, 8, 9)
- 1 150Ω (R5)
- 2 1kΩ (R16, 17)
- 2 1Ω or wire link (R14, R15)
- 1 10kΩ cermet trimpot, horiz (VR1)

Note: R10, 11, 12 and 13 are not required for the Player PCB.

Junction Box – if required

- 5 6-pin mini-DIN connectors
- 1 mounting box to suit

Software

The software files are available for free download via the EPE Downloads site, access via [www.epemag.co.uk](http://www.epemag.co.uk). Pre-programmed PICs are available from **Magenta Electronics** – see their advertisement in this issue for contact details.

Setting up

Once completed, the player stations need to be programmed with their ID number, which can be 1,2,3 or 4, and should be unique to that station. On first power up, the station ID is blank.

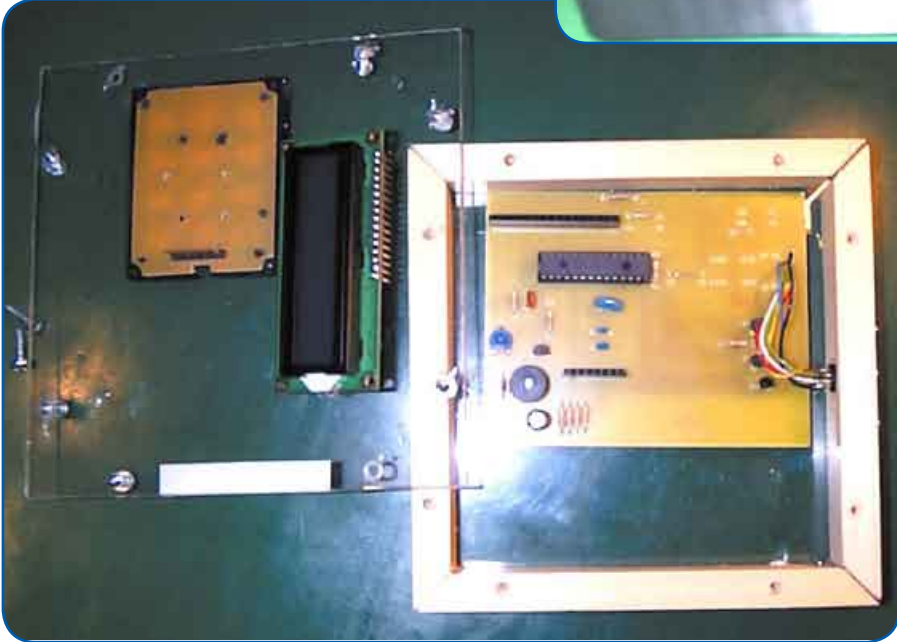
To set the ID number, press \* followed by digits 1,2,3, or 4. The unit will bleep and go back to a display



The ‘under-table’ junction box can use any plastic enclosure that can accommodate five six-pin mini-DIN sockets and a power connector for the power adaptor. The connectors are all commoned, apart from the power connector, as shown in Fig.10.



Completed optional junction box showing the five DIN sockets. The power connector is mounted on a side panel



The keypad and LCD module plug directly into the circuit board. The keypad protrudes slightly through the cutout in the clear plastic lid. The lid of the Banker unit also includes a power input connector

without a bank balance or last transaction value. Turn power off, wait a few seconds, and then back on again. You will then see the balance transmitted by the banker, and any last transaction details on the second line.

For example, on first power up of a system with the player station with an ID number will show;

BALANCE: \$ 01500  
Player: 0 \$ 00000

This shows the initial bank balance of \$1500 (the LCD display doesn’t have a £ symbol!), and there is no last transaction at this point. The second line always shows the last player to receive money, and how much.

## Playing

On first switch on, all players will see two lines on their displays as above. If Player 1 sends Player 2 \$100, the displays will update as follows after a few seconds;

### Player 1

BALANCE: \$ 01400  
Player: 2 \$ 00100

### Player 2

BALANCE: \$ 01600  
Player: 2 \$ 00100

### Players 3 and 4 (if constructed)

BALANCE: \$ 01500  
Player: 2 \$ 00100

If any player tries to send funds that would make them overdrawn, the Player station will bleep and display '\* OVERDRAWN! \*' and all displays will update their second line to;

Player: 0 \$ 00000

To send money, press #, followed by the player number to whom you want to send money. Then key the amount of money (up to 5 digits), and press # to send. A confirmation bleep will be heard with every key press. Pressing \* at any point while entering a transaction will cancel the transac-

tion, without any effect on displays or account balances.

If Player 1 is to pay \$120 to Player 2, Player 1 presses;

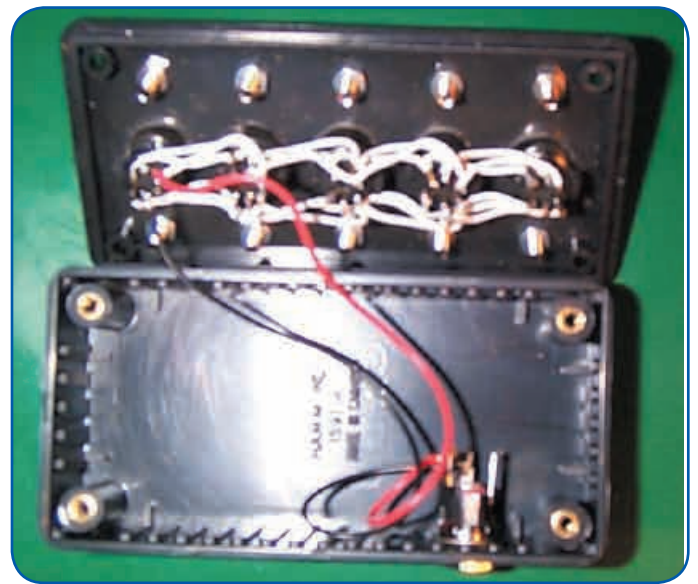
# 2 120 #

The Banker maintains its own balance, and 'Passing Go' money and any amounts from 'Community Chest' or 'Chance' are paid from the banker using the same process as above, starting

with the # key. Any amounts which should be paid to the Bank, are paid to Player 0. Hence, to pay \$50 to the Bank to get out of jail (!) means pressing;

# 0 50 #

Transactions are queued in the player stations until the next time they are 'polled' by the banker, which is in the sequence 1,2,3,4. Hence if two players enter transactions at the same time, for example, the players birthday scenario with \$10 from each player, the banker will simply action them one at a time until complete.



Wiring to the rear of the junction box 6-pin DIN sockets

The \$ and £ symbol are considered interchangeable here, sadly the LCD display character set does not include good old GBP.

## Ending play

In tests, an extra feature was found, which is to sell all property back to the Bank at the end of the game. The account balance for each player will therefore be equivalent to the cash float, plus the value of any property. Mortgaged property is, of course, sold back to the bank for the mortgage value.

Happy Monopoly!

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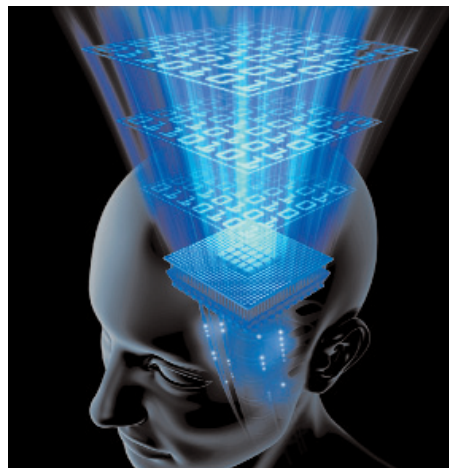
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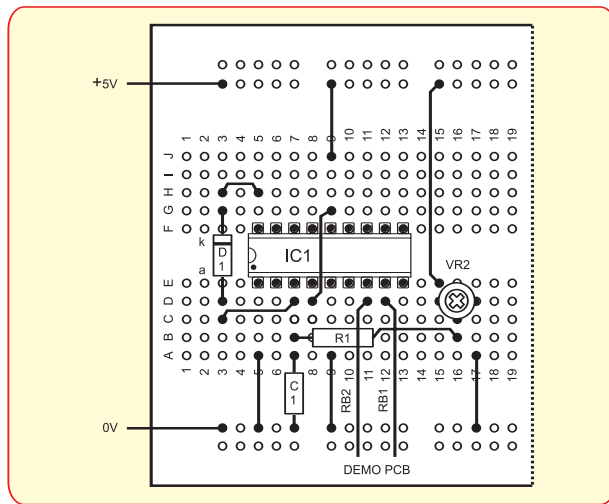


Fig.8.2. Additional breadboard layout for use with Fig.8.1

was originally supplied to *EPE* by reader Joe Farr when his RS232 PC control article (*EPE Serial Interface*) was published. The routine is shown in Listing 8.1.

It is the SETBAUD routine that is important during the setting up stage. The value associated with the Baud rate is obtained from a quite complicated formula, which takes into account the PIC's control clock rate (4MHz for this circuit) and which is discussed shortly. That value, 103 at this time, is that required for a 2400 Baud rate. It is placed into the PIC's SPBRG register, and the TXSTA and RXSTA registers are set with values that enable the PIC's TX and RX functions.

For some reason the SPBRG register is not listed in Microchip's .inc file, and so this is specified independently with the command during the basic initialisation routine following the CBLOCK section:

```
SPBRG EQU H'99'
```

This technique for specifying register equates values has not been discussed here before, but you will have seen it occasionally in the *Teach In* software, and if you've examined Microchip's .inc file. The technique is useful if you wish to allocate a specific register (normally

named by the user) to a specific address. The equated name goes at the far left of the ASM page. It is followed by 'EQU' and then the address to which you want to allocate it, in any of the numerical formats.

Via **FlushRXBuffer**, the PIC's RS232 reception buffer is then cleared to remove any possible previously received data. A return to the main program is then made.

### Baud rate calculation

The formula for calculating SPBRG values in respect of Baud rate is quoted in the PIC's datasheet. It is a bit fiddly to use each time it is needed and the author wrote a short routine for it as part of his *TK3* software, written in Visual Basic 6 (VB6). The heart of the routine is shown in Listing 8.2 and could be translated to suit other forms of Basic if desired. The values and other messages are output to screen Labels as part of the main VB6 program.

The *TK3* display screen is shown in Fig.8.3.

Listing 8.3 shows a worked example using Microchip's formula, and is for a Baud rate of 9600 at a clock rate of 3.2768MHz. Where Fosc is the PIC's clock rate and X is the SPBRG Value.

### Listing 8.1

```
SETBAUD      BANK1      ; Configure the baud rate generator
              movlw 103   ; BRG for 2400 baud from 4MHz,
                          brgh=1
              movwf SPBRG ; In bank 1
              movlw b'00100100' ; BRGH = 1(High speed, bit 2) &
                          ; ASYNC transmission (bit 5)
              movwf TXSTA ; In bank 1
              bcf STATUS,RP0 ; back to RAM page 0
              movlw b'10010000' ; ASYNC reception
              movwf RCSTA ; In bank 0
              call FlushRXBuffer ; Flush the RX buffer in bank 0
              return

FlushRXBuffer
              movf RCREG,W ; Flush the RX buffer in bank 0
              movf RCREG,W
              movf RCREG,W
              return
```



Fig.8.3. Screen dump of TK3's Baud rate calculating facility

### Listing 8.3

```
Baud = Fosc / (16 x (X + 1) for BRGH = 1
Baud = Fosc / (64 x (X + 1) for BRGH = 0
```

Microchip state that it may be advantageous to use BRGH = 1 even for slower Baud clocks, because its equation can reduce Baud rate error in some cases.

Transposing the formula when BRGH = 1, we get:

$$X = (\text{Fosc} / (\text{Baud} \times 16)) - 1$$

Thus for Fosc = 3.2768MHz and Baud = 9600 we get:

$$X = (3276800 / (9600 \times 16)) - 1 = (3276800 / 153600) - 1 = 20.333$$

Only integer (whole number) values can be used, so the calculated SPBRG value is 20. Putting the value of 20 into X of the formula, we get an actual Baud rate of:  $3276800 / (16 \times (20 + 1)) = 3276800 / 336 = 9752.38$

This represents an error of  $(9752.38 - 9600) / 9600 = 0.015873\%$ , which is immaterial.

Following the return to the main program after setting the Baud rate, the PIC's Timer 1 is initialised. This, and the timer's use are discussed later. The routing for transmission or reception is then selected.

The transmission routine is shown in Listing 8.4. Ignoring for the moment how the values to be transmitted are arrived at, the timer is reset, the Fig.8.1 oscillator triggered and the timer started. When the oscillator's cycle has completed, the timer is stopped. Now the letter 'S' (for Sync) is transmitted via the TXBYTE routine, which is shown in Listing 8.5. The purpose of sending this letter is to minimise the risk of the receiver receiving the value bytes in the wrong order.

## Listing 8.2

```
Public Sub Calculate_Click()

If BaudIndex > 0 Then C           = (XtalIndex / (BaudIndex * 64)) - 1
Else C                           = 0
If C > 0 And C < 256 Then
BRGH0                            = C
actualbaud0                     = XtalIndex / (64 * (CInt(BRGH0) + 1))
actualbaud0                     = Int(actualbaud0 * 1000) / 1000
error0                           = ((actualbaud0 - BaudIndex) /
BaudIndex) * 100
error0                           = Int(error0 * 1000) / 1000
Label1.Caption                   = "SPBRG = " & CInt(BRGH0)
Label5.Caption                   = "Baud = " & actualbaud0
Label7.Caption                   = "Error " & error0 & "%"
Else
beep
Label1.Caption                   = "NOT POSSIBLE"
Label5.Caption                   = ""
Label7.Caption                   = ""
End If

If BaudIndex > 0 Then C           = (XtalIndex / (BaudIndex * 16)) - 1
Else C                           = 0
If C > 0 And C < 256 Then
BRGH1                            = C
actualbaud1                     = XtalIndex / (16 * (CInt(BRGH1) + 1))
actualbaud1                     = Int(actualbaud1 * 1000) / 1000
error1                           = ((actualbaud1 - BaudIndex) /
BaudIndex) * 100
error1                           = Int(error1 * 1000) / 1000
Label2.Caption                   = "SPBRG = " & CInt(BRGH1)
Label6.Caption                   = "Baud = " & actualbaud1
Label8.Caption                   = "Error " & error1 & "%"
Else
beep
Label2.Caption = "NOT POSSIBLE"
Label6.Caption = ""
Label8.Caption = ""
End If
END SUB
```

## Listing 8.4

```
MAIN    clrf TMR1L                ; reset timer 1 LSB
         clrf TMR1H                ; reset timer 1 MSB
         bsf PORTA,1              ; set RA1 high to start cap charging
         bsf T1CON,0              ; start timer 1

M2       btfss PORTA,4            ; has cap reached RA4 trigger level?
         goto M2                  ; no
         bcf T1CON,0              ; yes, stop timer 1
         bcf PORTA,1              ; set RA1 low to discharge cap

         movlw 'S'                ; transmit 'S' for sync
         call TXBYTE
         movf TMR1H,W
         call TXBYTE
         movf TMR1L,W
         call TXBYTE

         call PAUSIT              ; allow time for cap to discharge
         call PAUSIT              ; allow time for cap to discharge
         goto MAIN                ; repeat
```

## Listing 8.5

```
TxByte nop
         btfss PIR1,TXIF          ; TX Buffer empty yet ?
         goto TxByte              ; No - Keep waiting
         movwf TXREG              ; Now empty - send this character
         return
```

The timer's MSB and LSB are then similarly transmitted, followed by a brief pause, and the process repeats, until the power is switched off.

At the TXBYTE routine a check is first made to see if the transmission buffer is empty:

```
btfss PIR1,TXIF ; is TX Buffer empty yet ?
```

If it is not empty, the checking continues in a loop until it is. It should be recognised that there is a delay dependent on the Baud rate selected, which determines the rate at which a value in the buffer is transmitted.

When the buffer is empty, the new byte to be transmitted is placed into the buffer:

```
movwf TXREG ; Now empty - send this character
```

Once a value is within the buffer, no further program action is needed for transmission, the PIC automatically takes care of it.

First, the PIC's RCSTA and TRISB registers are set for reception. Then, at R1, a check to see if any data has been received, looping if it has not:

```
R1 btfss PIR1,RCIF ; Check for any RX'd data
   goto R1          ; Nothing RX'd
```

When it has been received, the data is loaded into W, via **movf RCREG,W**, and a check made to see if the data is 'S', the sync command transmitted. If not, the loop repeats.

If the data is correct, Port A is toggled to signal to you, via a multimeter if desired, that correct reception has taken place.

In theory, of course, it is possible that counter value data could also have the same 8-bit value as the ASCII for letter 'S', but the technique reduces the chances of data being received in the wrong order. A better technique using checksums, was discussed by Mike Hibbett in *PIC 'n Mix* Jan '08.

Now the two counter bytes are awaited, MSB and LSB, and loaded into W when received. Next, the RCSTA and TRISB registers are set to allow Port B to be used to send data to the LCD:

```
movlw 0
movwf RCSTA
BANK1
movlw b'00000000' ; set TRISB for LCD output
movwf TRISB
BANK0
```

The received two-byte value is now digitised and output to the LCD on its Line 1. Each time a fresh batch of data is received, an 8-bit counter is incremented and its value is shown on Line 1 following the TX value. The process then repeats for as long as data is transmitted - until the power is switched off in this demo.

Data reception is slightly complicated by the fact that both the LCD and the RS232 pins are within Port B.

Consequently, a few housekeeping commands are required to ensure correct functioning of the TRISB register, study the main program.



## Time-out

In a real program, rather than just a demo, it is possible that TX/RX could be interrupted by a fault, such as the TX PIC going off-line or the connecting wires being broken. If this were possible, the use of a time-out would be beneficial.

A time-out option can be easily inserted into the reception routines, resetting a timer each time reception is required and incrementing it until data is received. If data is not received within a given period, a termination routine would be entered.

## Timer 1

We are also introducing here the use of the PIC16F628's Timer 1. Unlike the 8-bit Timer 0 previously discussed, Timer 1 is a 2-byte (16-bit) counter, with its MSB and LSB held in TMR1H and TMR1L respectively.

The PIC on the breadboard uses a software routine which is somewhat similar to analogue-to-digital conversion (ADC). The PIC's Timer 1 is used to monitor a variable voltage on its pin RA4. It is not a true ADC, as the PIC16F628 does not have the facility, unlike some PICs. It is controlled by register T1CON.

The timer can have any one of eight prescale values set to be active via its bits 5 and 4:

```
11 1:8
10 1:4
01 1:2
00 1:1
```

The timer is stopped when bit 0 = 0, and started when bit 0 = 1. To select Timer 1 for a prescale value of 1:8 requires the following commands:

```
movlw b'00110000' ; set timer 1 for
;prescale 1:8, and timer off
movwf T1CON
```

To start the timer you simply use the command

```
bsf T1CON,0
```

and to stop it again

```
bcf T1CON,0
```

The timer can be incremented from several sources, either internally or externally. It is used in this application so that it is incremented by the PIC's oscillator, at one quarter of the nominal rate, ie at 1MHz for a 4MHz clock. See the PIC's datasheet for more information on Timer 1.

## Variable voltage detection

The circuit at the bottom of Fig.8.1 is quite simple in operation. Capacitor C1 is initially discharged via diode D1 when PIC pin RA1 is taken low. The timer is simultaneously stopped and reset. When RA1 is set high again, the timer is started and C1 charges up via the wiper of preset VR2 and resistor R1. When the voltage on C1 reaches the threshold of Schmitt trigger input RA4, the PIC regards the voltage on that pin as logic 1. As soon as it does so, it stops the counter and reads its value. RA1 is again taken low and the process repeats.

The rate at which C1 charges to the RA4 threshold depends on the voltage supplied by VR2, which can be varied by the user. The timing value varies with the rate of charge. Beware that the minimum voltage VR2 can supply to ensure that C1 charges up adequately is about 3.0V.

## ADC techniques

It may seem that this simple circuit could be made the source for analogue-to-digital conversion (ADC), but in fact it is not reliable enough for that. It is inherently imprecise in its timings, and the rate of charge is not linear with the applied voltage. There are ways in which a PIC such as the PIC16F628 can be made to behave as an ADC, but such matters are a bit complicated and if you need ADC facilities it is better to choose a PIC already with the facility.

There are many examples of a PIC16F87x device's ADC facility illustrated in *EPE* constructional articles, many of them by the author. The software for these designs can be downloaded free via [www.epemag.wimborne.co.uk](http://www.epemag.wimborne.co.uk). However, it is worth highlighting the general ADC principle of an example PIC, the 16F628, even though that PIC is not used for this *Teach In*. Sooner or later you are going to want to use one of the 87x family, or others that have ADC.

First, it must be noted that the 876 must be set for analogue mode for the ADC to be used, and which pins are to be used for ADC input, of which the 87x has eight, RA0 to RA5, plus RE0 to RE2. This is done with a couple of commands in Bank 1, in which register ADCON0's bits 5-3 hold the port pin selection code. To set all available pins for ADC requires these pins to be set high, B'00111000'.

There is also a choice of conversion rate which can be set, related to the PIC's clock rate (Fosc), using ADCON0's bits 7 and 8, with a code of 00 providing the fastest rate of Fosc/2. But it must be noted that the conversion rate choice must take into account what the Fosc rate actually is, as some conversion rates are not possible with some combinations of conversion code. With an Fosc rate of 5MHz, for instance, the fastest conversion rate is 1.6µs, requiring a code of 01 (Fosc/8).

Whether or not the ADC is actually active is determined by the setting of ADCON0 bit 0 (ADON), 1 for on, 0 for off. To start the conversion ADON bit 2 (GO/DONE bit) must be set. It is automatically cleared when the conversion is complete.

In addition, register ADCON1 determines a number of factors, such as which pin actually feeds to the internally-multiplexed ADC, and as to whether or not the

ADC's reference is to be set internally or externally (via pins RA2 and RA3).

The F87x has two registers which hold the 10-bit converted ADC value. There is a choice: whether or not the first register of the pair (ADRESH) holds bits 9 and 8, with the second register (ADRESL) holding bits 7 to 0 (right justified). The alternative is for ADRESH to hold bits 9-2 and ADRESL to hold bits 1-0 (left justified). The selection is determined by the setting of ADCON1 ADFM bit (7), 0 = left justified, 1 = right justified.

The PIC's data direction registers (TRISA and TRISE) must also be told which pins are to be used for input in the normal way.

An example of doing an ADC once the above requirements have been set is simply:

```
GETADCVAL    bsf    ADCON0,GO
; start data conversion
GETADC       btfsc   ADCON0,GO
; is conversion complete?
goto GETADC
; no
movf ADRESH,W
; yes, get ADC MSB val
movwf REGA1
BANK1
movf ADRESL,W
; get ADC LSB val
BANK0
movwf REGA0
return
```

Here the two bits of the conversion register are stored in user registers REGA1 and REGA0, for later use by the program. It should be noted that the 87x holds the ADRESH register in Bank 0 and the ADRESL register in Bank 1 (this is not the case for all PICs that can do ADC).

You should also be aware that there is a time lag that must be allowed when changing ADC channels within a program. A call to a delay routine such as PAUSIT, normally takes care of it.

See the PIC16F87x datasheet for more information on that PIC's ADC use, in particular its Figs 11-1 and 11-2 in Section 11.0.

## PICs to PCs

As explained earlier, PCs having RS232 serial (COM) ports can be used with a PIC, using an RS232 interface chip, such as the

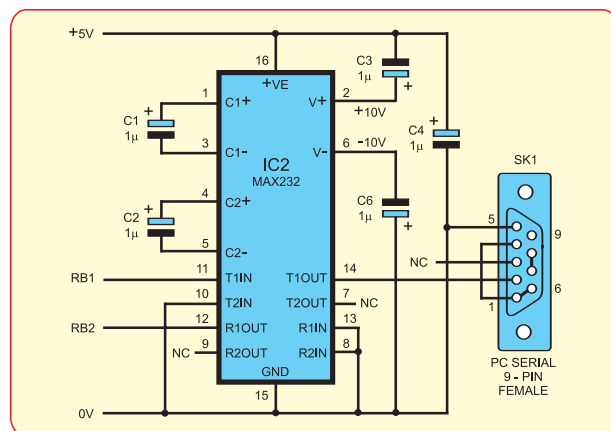


Fig.8.4. RS232 interface between PIC and PC

MAX232. Software for such use was written by Joe Farr for his *Serial Interface* article. It was written in VB6 and has been used many times in *EPE* projects. Copies of the article are available via the *EPE* Back Issues department. The software is also available via [www.epemag.wimborne.co.uk](http://www.epemag.wimborne.co.uk).

The circuit for an RS232 PC interface is shown in Fig.8.4.

## Reaction Timer

There's room this month to provide you with a Reaction Timer. It's circuit is shown in Fig.8.5, and the breadboard layout in Fig.8.6. Assemble it and load the PIC with **TEACHINH02.hex**.

When the program is run, the message 'REACTION TIMER' is shown on LCD line 2 and LED D2 is turned on. Now press switch S2 to start a random delay. At the end of the delay, LED D1 comes on. As soon as it does, LED D2 is turned off and a timer based on Timer 1 is started. Press switch S1 as soon as you see LED D1 lit.

The time between D1 coming on and you pressing S1 is then displayed on line 1, in seconds, to three decimal places.

During the time between D1 coming on and you pressing S1, Timer 1 counts at the PIC's clock rate divided by four – every microsecond for a 4MHz clock rate. Each time Timer 1 rolls over, a counter is incremented. When S1 is pressed, The counter value is multiplied by 63356 and added to the timer's value. The answer is divided by one million and displayed as a seconds count.

In this instance, the division is done by simply placing a decimal point in the display at the appropriate position, and omitting the final three digits of the converted decimal value. The delay value is updated in a semi-random fashion while the wait for S1 to be pressed is in progress.

Should S1 not be pressed before the counter rolls over, an overflow condition exists and is displayed on screen; LED D2 comes on again. S2 must be pressed again to restart the process from the beginning.

Study the ASM file's code to see how the whole program operates.

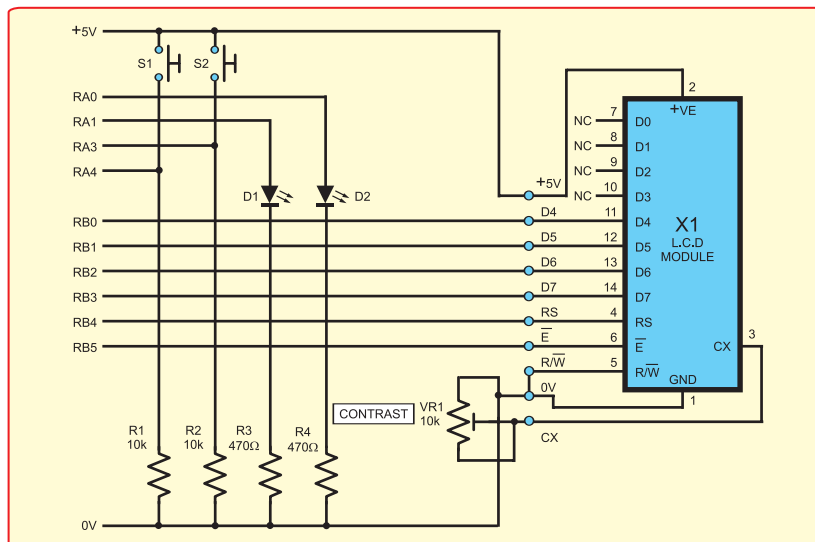


Fig.8.5. Reaction timer circuit diagram

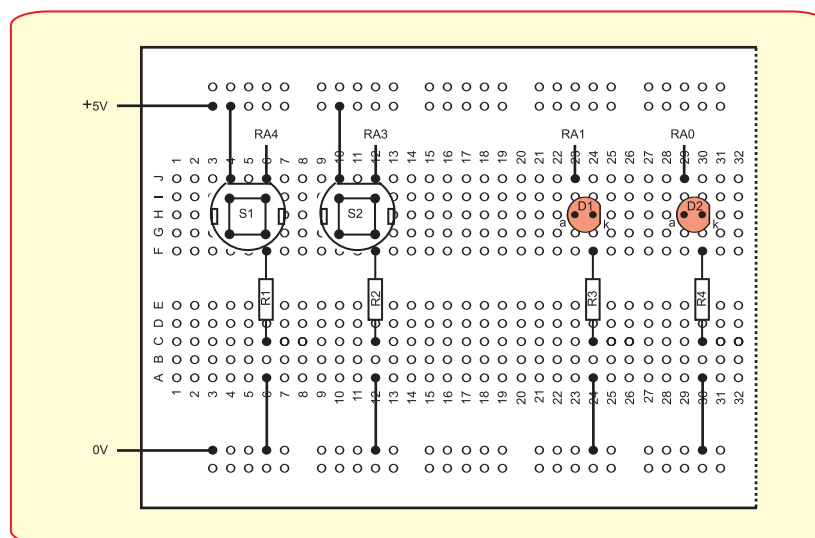


Fig.8.6. Breadboard layout for Fig.8.5

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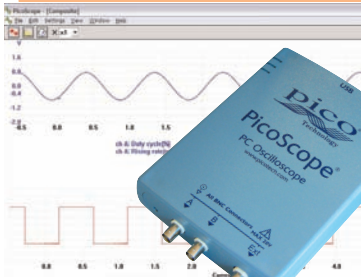
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## Low Voltage Flasher – *Flashy Kick-start Light*

IN Fig.1 is shown the circuit for a very efficient, low voltage white or blue LED flasher. It is based on the low voltage ZSCT1555 timer IC, which has a guaranteed operating voltage of 0.9V to 6V. The design is optimised for 1.5V, and would flash brightly for up to three years off an alkaline 1.5V AA battery (current consumption is just over 100µA).

IC1 is wired as a standard astable oscillator. As shown, the circuit sends short pulses through inductor coil L1 at IC1 output pin 3. These energise L1 which, when IC1's output goes positive, sends a pulse of back-EMF through white or blue LED D1.

Ordinarily, it would not be possible to flash D1 off a 1.5V supply, since blue and white LEDs require a much higher forward voltage (typically between 4V and 5V for a white LED). However, the back-EMF creates a voltage significantly higher than the supply voltage. Since IC1 is rated 6V maximum, it is able to endure the higher 'kickback' pulse.

You might think L1 and D1 in series might appear to be a short circuit. However, given the 1.5V supply voltage, this is not enough to overcome the forward voltage of a blue or white LED. With this 'short circuit' in mind, however, and the voltage rating of IC1, the battery voltage of B1 should only be raised with caution, nor will the circuit work properly with other than blue or white LEDs, unless these are wired in series with rectifier diodes, to raise the combined forward voltage.

Inductor L1 is the same as the coil used for the recent *Electrosmog Sniffer* (Feb

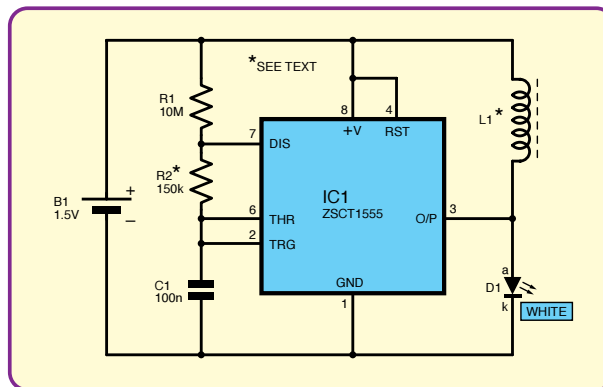


Fig.1. Circuit diagram for the long-life Low Voltage Flasher

'08 issue). However, a 12V relay (not a miniature relay) coil may be employed on condition that this does not have an internal diode to suppress back-EMF. In this case, some experimentation may be required with the value of resistor R2 to obtain optimal brightness for LED D1.

One should not exceed the point of maximum brightness for the LED, or this will squander power, and may raise 'kickback' pulses to an unsafe level for IC1. The value of resistor R2 may also be reduced to create a more efficient (and less bright) flasher. Resistor R1 controls the rate of flash, which is about 1Hz with the value shown.

**Thomas Scarborough,**  
Cape Town, South Africa

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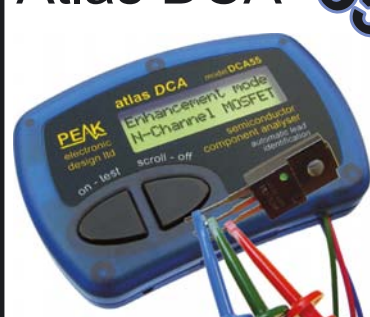
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# Circuit Surgery

Ian Bell



## More on Ground and Earth Loops

Following on from last month's 'surgery' on ground loop (also known as earth loops) problems, as posed on the *Chat Zone* (<http://www.chatzones.co.uk/cgi-bin/discus/discus.cgi>) forum by **zapper**, we continue by looking at differential signals and signal guarding.

### Differential signals

Differential signals can help overcome noise problems, including those due to ground loops. Differential signals are carried on two wires (ie two voltages  $V_1$  and  $V_2$ )

other than ground. Fig.8 represents a differential signal with a peak voltage of 2V and a peak-to-peak voltage of 4V, in fact, the *difference* between  $V_1$  and  $V_2$  in Fig.8 is the same as the signal in Fig.7a last month.

With a differential signal, if the signal voltage on one wire increases then the signal voltage on the other wire decreases by exactly the same amount. The actual signal is equal to the difference in the voltages on the two wires measured with respect to ground.

So, if the two voltages on the two wires are  $V_1$  and  $V_2$ , the signal  $V_s$  is  $(V_1 - V_2)$ . If

the two wires run closely parallel together, then the same error (eg mains hum, interference etc) will occur on each wire. If this error is  $\delta$ , then the voltage on wire 1 will become  $V_1 + \delta$  and the voltage on wire 2 will become  $V_2 + \delta$ . The signal is the difference between the two wires, that is  $(V_1 + \delta) - (V_2 + \delta) = (V_1 - V_2)$ , which is the same as without the error. This is illustrated in Fig. 9 and 10.

The error voltage  $\delta$  which we have just discussed is common to both halves of the differential signal. It is, therefore, called a

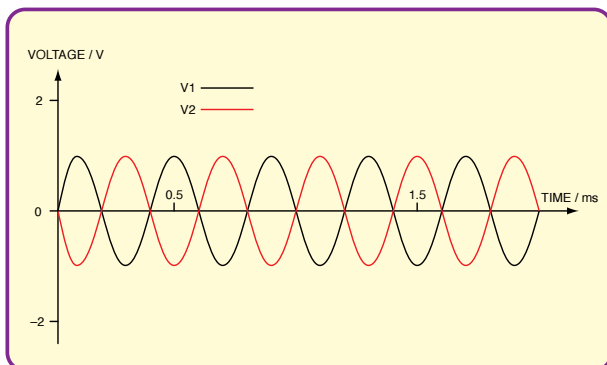


Fig.8. Differential signal. The signal is the difference between  $V_1$  and  $V_2$  and therefore has a peak value of 2V and a peak-to-peak value of 4V. The difference between these waveforms is the same as the signal in Fig.7a (last month)

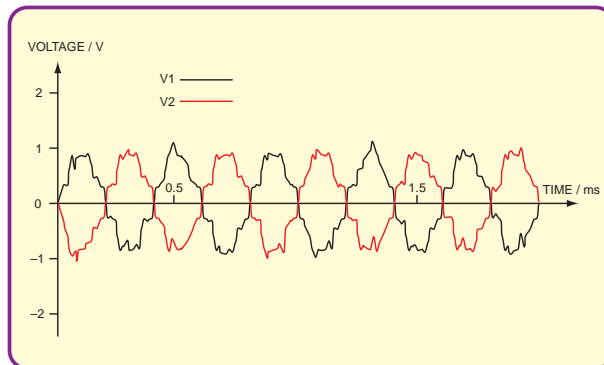


Fig.9. Differential signal with a common-mode noise. The difference between these waveforms is the same as the signal in Fig.7a (last month)

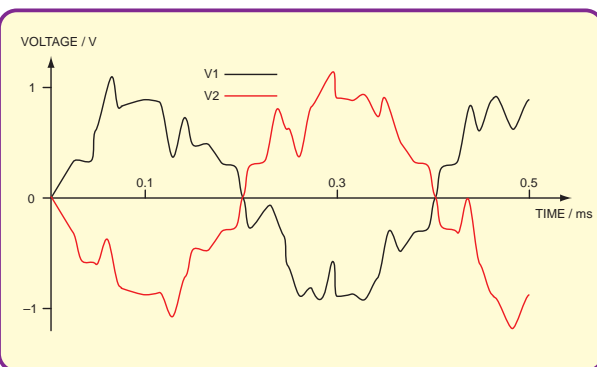


Fig.10. Zooming in on the first part of Fig.9 to see more clearly that the noise is common-mode — ie the error goes in the same direction on both waveforms and hence that the difference between these waveforms is the same as the signal in Fig.7a (last month)

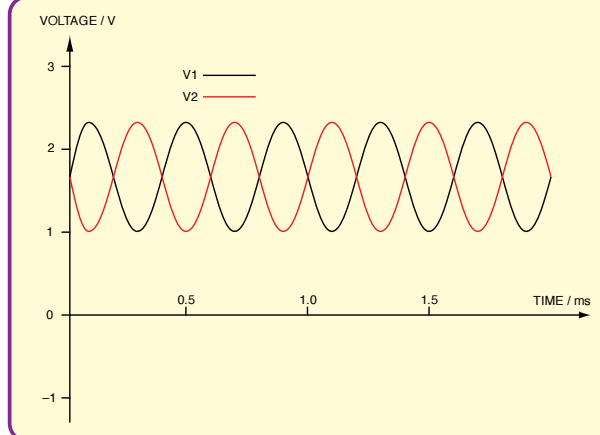


Fig.11. A 4V peak-to-peak differential signal with a 1.5V common-mode voltage



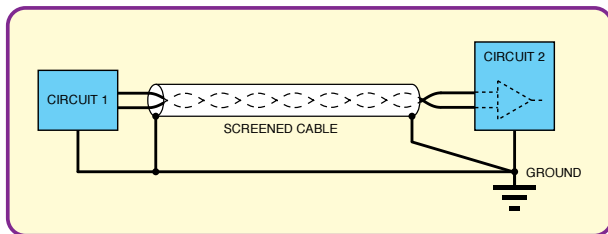


Fig.12. Differential and balanced interconnection

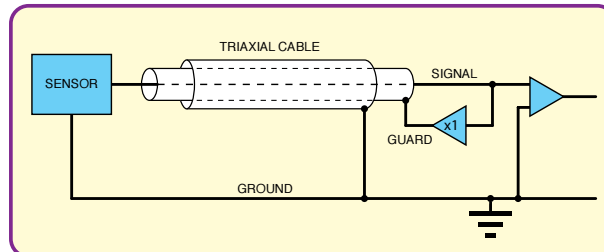


Fig.14. Guarded signal connection

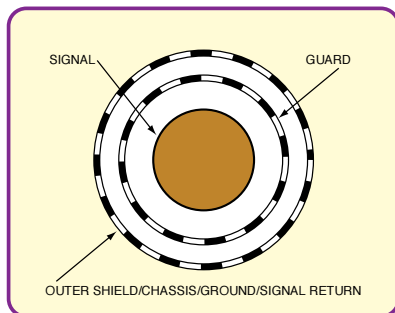


Fig.13. Triaxial connector used with triaxial cables for guarded connections

common-mode voltage and noise of this form is called *common-mode noise*. If the two voltages on the two wires are  $V_1$  and  $V_2$ , the common mode signal  $V_{cm}$  is  $(V_1 + V_2)/2$  (ie, the average of the voltage on the two wires). Differential signals quite often have DC common-mode voltages, for example a 4V peak-to-peak sinewave differential voltage with a 1.5V common mode DC signal is shown in Fig.11. Differential signals are commonly connected using screen twisted pair (STP) cables, as shown in Fig.12.

### Balanced connections

Balanced connections are similar to differential signals in that the signal is carried on two wires and connects to a differential amplifier input. However, the signal does not have to be equal and opposite (ie differential). The key point is that impedances of the two signals are balanced, so that noise picked up by the two conductors will appear as a common-mode signal at the input of the differential amplifier.

Balanced and differential signals are commonly used in professional audio systems. Balanced differential signals provide good immunity to ground loop hum as long as the shield ground does not share a path with the signal ground.

Signal guarding is concerned with getting the most out of screened cable connections, particularly when connecting very low-level signals from high impedance sources to high precision circuits (typically in sensor systems). In such cases, effects such as leakage currents in the cables and cable capacitance can cause significant errors.

Signal guarding uses triaxial cables and connectors (see Fig.13), which have an inner conductor, carrying the signal of interest and two layers of shielding. The inner shield is connected to a signal of equal voltage to the signal provided by a unity gain amplifier (see Fig.14). This means that there is a zero voltage difference between the signal and inner shield so the leakage currents (and capacitance effects) are minimised. The outer shield is usually grounded and provides interference protection for the guard signal.

As an example of how guarding works, consider the schematic in Fig.15a, for which an equivalent circuit is shown in Fig.15b. Here we are trying to measure the resistance of a sensor,  $R_S$ , which has a very high resistance value and therefore leakage through the cable insulation resistance  $R_C$  is significant. We apply  $V_M$  and measure  $I_M$  – this should give the value of  $R_S$  as  $V_M/I_M$ , but actually gives us this parallel combination of  $R_S$  and  $R_C$  due to the leakage current  $I_L$ .

Using a guard (Fig. 15c and 15d) means that the voltage across  $R_{C1}$  between the inner conductor and guard is zero and hence no leakage current flows. The buffer amplifier has no difficulty in supplying the guard-to-ground leakage current  $I_{L2}$  and this does not disrupt the measurement.

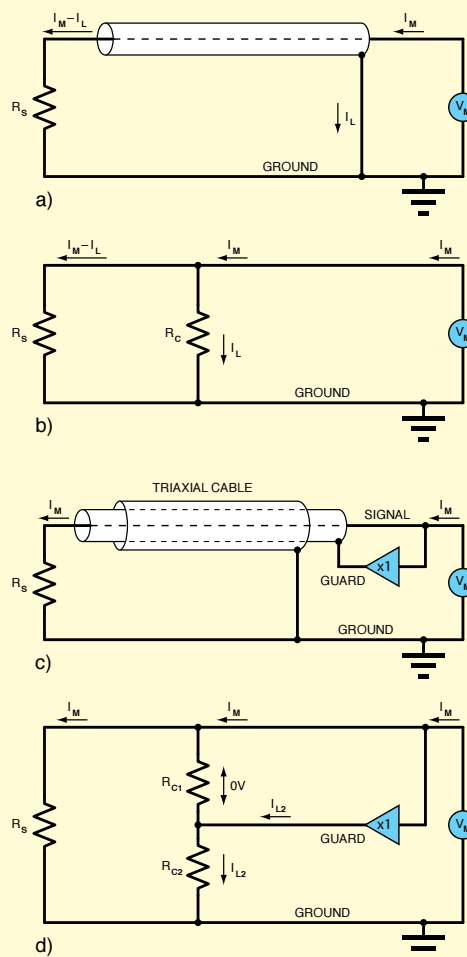


Fig.15. Guarded resistance measurement: a) non-guarded setup, b) non-guarded equivalent circuit, c) guarded setup, d) guarded equivalent circuit

**EPE** EVERYDAY PRACTICAL ELECTRONICS

### PLEASE TAKE NOTE

#### Circuit Surgery

(April '08)

Page 57, all references in main text to MAX5895 should read MAX8595X. Caption for Fig.14 should read MAX8595X rather than just MAX8595

## PIC controlling matrixed LEDs while maintaining constant brilliance

**R**eader *John Pugh* recently contacted me with a problem over maintaining constant brilliance of matrixed LED displays, a good example of which is shown in the photograph.

He has come across this brilliance problem several times over the years and it has left him high and dry for an explanation. He first came across it while using a quad 7-segment LED display. He has been unable to figure out why such a device glows more brightly when a digit '1' is displayed using only two of its segments and a digit '8' which glows much more dimly when all its segments are lit. He has used various techniques to multiplex these displays, but the problem still persists.

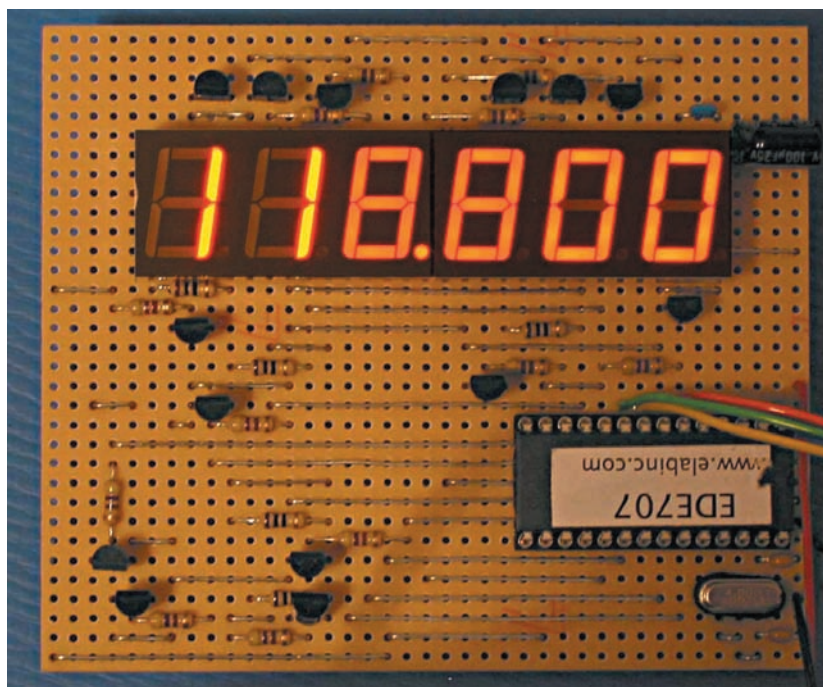
Belonging to a local flying school, from where he regularly flies, the chief flying instructor there set him a challenge to design and build a project for the school. The project utilises a 6-digit display and was working extremely well, except that he still had the problem of varying digit brightnesses. He thought this must be something to do with the current flowing into the segments, even though each one has its own resistor.

### Early thoughts

He had tried various power supplies, some of which were quite capable of supplying 2A or more, but the problem still persisted. He trawled the Internet for an answer, but was unable to find a proper solution. He even tried switching both the common anode and each separate cathode of these displays with their own transistor, thinking that this would surely solve the problem, but nothing changed. He asked if he had done something obviously wrong and was there a simple answer to the problem.

At first I thought it might be a problem in the software multiplexing routines, and a bit of a discussion on that ensued. I also looked at his PIC ASM file, but could see nothing untoward there. It was a bit baffling, as I'd never had the problem. It is usually imperative that multiplexing routines are constant in their timings at all stages, especially when displays are concerned.

He sent me a variety of circuits which he had been trying without success (the block diagram for one is shown in Fig.1). My immediate thought then was – could it be that his displays were faulty somehow? I asked him what happened if he sent '1E1E' or 'E1E1' to the displays, setting a code for letter 'E'. In other words, using different segments for the characters, and also swapping the characters over. There seemed the



*The original display brilliance problem*

possibility that there might be a short circuit between two or more segments during the multiplexing.

He replied that he had now tried out the suggestion. Driving the displays to show '1E1E1E' revealed the usual problem even though the '1' and the 'E' used different segments. He also tried outputting '174508' on the display, which starts with two segments lit on the left and increases by one until all segments are lit on the right. This actually showed that the '1' and the '7' were much brighter than the others but the '4508' digits were not discernibly different.

### Voltage readings

I asked if he had tried other multiplexed display modules, which he said he had. I went on to suggest that it could be that the transistors were not providing the current needed at all times, drawing too much when all segments were on and overloading, rather than when just a few are on. So I asked him to set a digit for all segments on all the time and to measure the voltage across each segment, then to compare the readings with those when just one or two segments were on. He took those measurements and reported back:

*With all displays showing '1' the voltage across a segment was 1.066V but with all*

*digits at '8' the meter read 0.961V across the same segment. I measured other segments as well, but the readings were in the same ball park, plus or minus a few millivolts. That much difference in voltage across a pulsed LED is probably substantial I think. I do believe you have possibly hit the nail on the head! The transistor could well be into saturation with all segments illuminated, possibly with more than three segments on.*

*This probably explains why my earlier test with increasing the number of segments lit from left to right revealed that digits with four segments or more lit showed indistinguishable differences in brightness. The transistor must have been overloading at this point, possibly unsurprising really with segment resistors of 10 ohms. Correct me if I am wrong, but I understand it is normal to use lowish value resistors in this situation.*

*Having also looked at the datasheet for a typical BC548B, which I am using in my circuit, the maximum continuous collector current allowed is 100mA. Without knowing the actual rate of multiplexing these transistors, it is difficult to know if they are being overdriven.*

*This could very easily be my problem it seems. What would you do armed with this latest knowledge, would you increase the*

value of the eight ballast resistors I am using at the segment cathodes until all digits appear evenly lit, or would you change the transistor for a more beefy one, such as the ZTX605 Darlington transistor? I have used the latter in many PIC projects as it is a physically small device, similar to the BC548B.

I would like the display to remain as bright as possible because I want to use a filter in front of it to make it look neater and more professional. The data sheet for the ZTX605 shows a maximum continuous current of 1A and a peak pulse current of 4A!

## Penny dropped!

Then the penny dropped for me – using 10Ω resistors for each segment? That resistance value is far too low for an LED segment's long term safety under normal conditions, although the pulse widths inherent in the multiplexing will make a difference to the permissible current.

The current would also be too high for the PIC to sink or source, but he had previously taken that into consideration by using PIC-driven transistors in buffer mode to sink the LED segment current. (It is also imperative at any time to remember that although a segment's ballast resistor may be of a satisfactory value for the segment and a single PIC pin, a PIC's port can only allow a total current of so many milliamps through it at anytime – a value dependent on the PIC type – see its datasheet).

As things stood with John's circuit, the 10Ω ballast resistor would limit the segment to passing about 300mA under normal conditions, assuming a 5V supply and an LED voltage drop of about 2V or so. Without knowing the actual characteristics of the LEDs John was using, that mA value seemed far too high, it even exceeded the limits of the anode-driving buffer transistor.

Certainly John was getting good brilliance in principle for a segment, but it seemed that brilliance was close to being incandescent rather than that electronically derived in the normal way for LEDs! So, yes, the transistors were not providing the power needed at all times.

Personally, I tend to use ballast resistors of around 470Ω with a 5V supply and an LED forward voltage drop of about 2V-ish.

The transistor-driving resistors would be between about 1k and 10k, depending on the transistor type I was using, and the overall current drawn through it.

To remind you, the current ( $I$ ) drawn through an LED is:

$$I = (V_{in} - V_f) / R$$

or rearranged to make  $R$  the subject:

$$R = (V_{in} - V_f) / I$$

where  $I$  is the current  
 $V_{in}$  is the supply voltage  
 $V_f$  is the LED's forward voltage drop  
 and  $R$  is the value of the ballast resistor

## More feedback

John then came back to me with an explanation of why such low value ballast resistors were being used.

In the datasheet for the EDE707 Display Driver PIC being used along with a Kingbright BA56-12EWA Triple Common Anode 7-Segment Display, it explains in detail why 10Ω resistors are used. It also describes how the value of the segment current can be calculated:

Segment current can be approximated by the formula:  $0.125(3.8/R)$ , where 0.125 is the on period of the duty cycle. 3.8V is the supply voltage minus the two transistor voltage drops, and  $R$  is the segment series resistor value.

In my project this formula gives me a segment forward current of 47.5mA. An oscilloscope shows that the duty cycle is on for 12.5% and off for 87.5%. This is one-eighth of the time, since the EDE707 has been designed for up to eight digits, only six of which I am using. The datasheet on the Kingbright display

for my high-efficiency red version gives an absolute maximum rating of 160mA for the peak forward current. A note below the absolute maximum ratings table states that this maximum rating of 160mA is for a one-tenth duty cycle with a 0.1ms pulse width. EDE707's duty cycle is one-eighth.

I have now established that this is 0.13ms at the PIC anode drive outputs, which shows that my segments are pulsed for about 0.03ms (30%) longer than that quoted in the display's datasheet and my duty cycle is also slightly longer at one-eighth instead of their one-tenth. I am, however, only passing 47.5mA through each segment, which is under one-third of the maximum of the 160mA permitted.

The anode transistors have now been substituted with the more beefy ZTX605 Darlington. My display problem is no longer evident. All segments are now illuminated evenly and very brightly.

It could well be that using the high gain ZTX605 Darlington ensures a rapid turn on of each display and is a good move anyway.

So the moral of this tale is that if you want higher LED brilliance, either use a high brightness type rather than winding up the current flow, or study datasheets in absolute detail to understand pulse width manipulation and restrictions. Also remember that a PIC-driven circuit problem might not be caused by software, but by hardware.

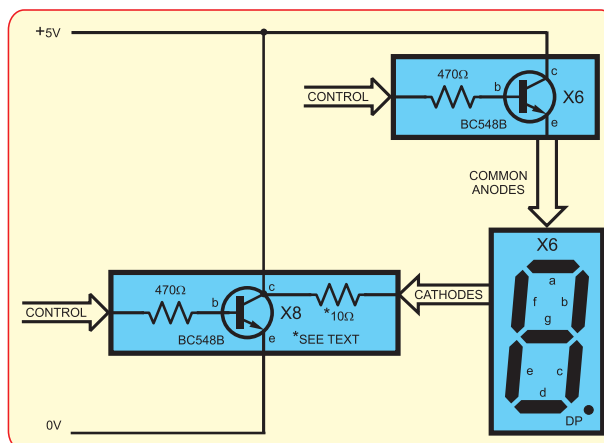


Fig. 1. Block diagram of the problem circuit

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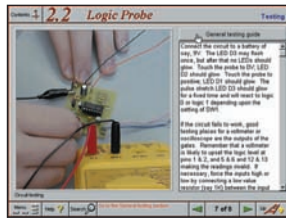
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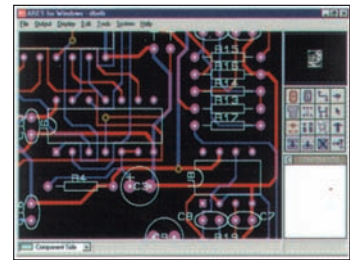


Logic Probe testing

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The projects on the CD-ROM are: Logic Probe; Light, Heat and Moisture Sensor; NE555 Timer; Egg Timer; Dice Machine; Bike Alarm; Stereo Mixer; Power Amplifier; Sound Activated Switch; Reaction Tester. Full parts lists, schematics and p.c.b. layouts are included on the CD-ROM.

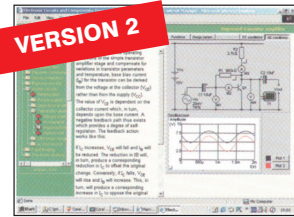
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PCB Layout

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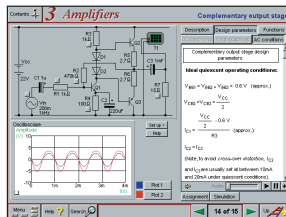
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## ANALOGUE ELECTRONICS

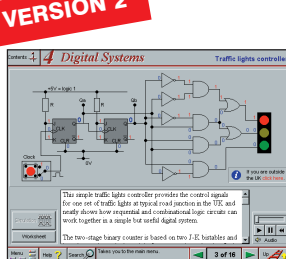


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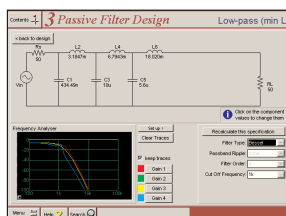
## DIGITAL ELECTRONICS V2.0



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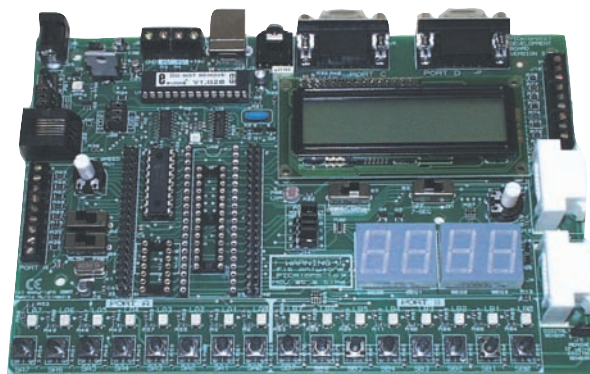
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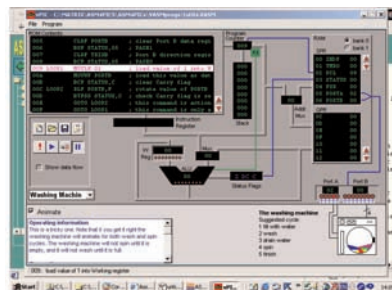
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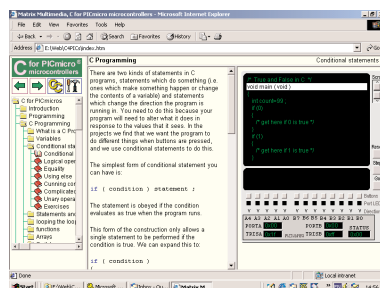


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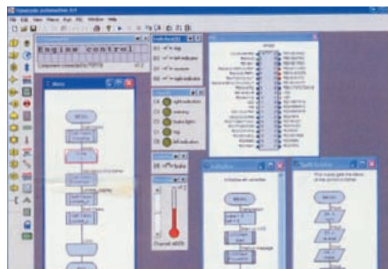
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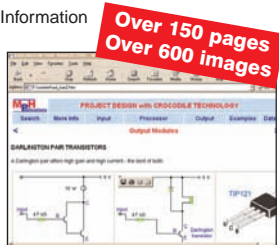
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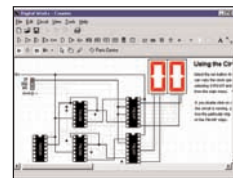
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# READOUT

Email: [editorial@wimborne.co.uk](mailto:editorial@wimborne.co.uk)

**John Becker addresses some of the general points readers have raised. Have you anything interesting to say? Drop us a line!**

All letters quoted here have previously been replied to directly.

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## ★ LETTER OF THE MONTH ★

### More on Linux and web security

Dear EPE,

I read with interest Doug's letter in the April issue, and Alan's reply on PC security. All of the suggested are, I am sure, very fine products and will no doubt protect the average user from all but a sustained and directed attack on their PC, but all the suggested approaches require 'extra' software to be running, reducing the resources available to actually do the work you want the computer to do.

While I appreciate that you stated it isn't possible to run comprehensive reviews on all products, I do feel one product was completely overlooked, which properly deployed removes the need for any anti-virus (AV) and spyware. I am, of course, referring to Linux.

Now, before you switch off and think, 'I can never manage without my Windows-only programs, so this is not for me', please read on. I am fully aware that despite the fact that there is an enormous (mostly free) array of software available for Linux machines, there is always a must-have piece of software you just can't find a replacement for, for which I have three solutions, but before them, a little about Linux, and why you should consider using it.

Linux distributions (distros) have developed beyond all recognition in the last three to four years, and in my experience they are as intuitive to adapt to using as moving from one version of Windows to another. I have tried a few distros over time and have now settled firmly on Ubuntu ([www.ubuntu.com](http://www.ubuntu.com)) as my distro of choice. It is easy to use, well supported, and has vast repositories of free software, including PCB designers and circuit simulators.

As with a lot of Linux distros, once downloaded and burnt, the CD image is a live CD, allowing you to boot your PC to Ubuntu without interfering with anything currently installed. This allows you to try before you buy, although of course there is no buying, it's free (Ubuntu is free, even for commercial use!).

Be aware though, that as you would expect, boot up times and general running is slower from the CD than an installed version. The live CD provides a very useful tool for accessing your PC in the event of an operating system failure (either Windows or Linux), allowing you to access the Internet to search for solutions, and access files on your hard drive(s).

Currently, there are no known 'live' Linux viruses, and from my experience and the research I have done, I have become an advocate of the theory that it would be virtually impossible to create a successful one. All the distros I have tried have come with a built-in firewall that has passed with flying colours all the 'Shields Up' tests ([www.grc.com/x/ne.dll?bh0bkyd2](http://www.grc.com/x/ne.dll?bh0bkyd2)). I can find no evidence of spyware, worms, etc for Linux, and so beyond run-

ning the operating system, there is no requirement for AV, extra firewalls, or spyware programs; releasing ALL of the computer's resources to do the work you want the computer to do.

Furthermore, features like the ext2/3 file systems not needing to be defragged, and to date (three years in) I have not found that my computer gets slower and slower, requiring a complete reinstallation of the operating system, all drivers, and software, means you will spend much less time house-keeping your PC, and more time using it. The ability to easily allow or deny access to directories and individual files is also very useful and adds more security.

Now my three solutions to running your 'must have' Windows software on a Linux machine: They are in the order I would try them, moving on to the next solution if required.

1. WINE ([www.winehq.org](http://www.winehq.org)) – Think of Wine as a compatibility layer for running Windows programs. A vast array of Windows software runs under it, including MPLAB. WINE is an alive-and-kicking project, for which I receive regular updates.

Windows software is installed as you would on your Windows operating system, eg by running the *install.exe*, and off you go. You do not require Windows for this solution and so this is a truly free solution.

2. VirtualBox ([www.virtualbox.org](http://www.virtualbox.org)) – Installing VB (free) in your Linux distro allows you to create virtual machines within your Linux system. Each machine shares the hardware resources, such as memory, but can almost be thought of as separate computers. On a virtual machine within a Linux operating system, you can install your Windows operating system, but set the hardware such that there is no network (Internet) connection. In this way, isolated from the world-wide web, your Windows machine will be safe from the dangers contained within. You can minimise the operating system software installed, releasing resources to work for you.

There is a feature to use a shared folder to allow you to transfer files between your Windows and Linux machines, but I tend to use a USB memory stick for the job. You can have machines for Windows 98, XP and even other Linux distros, or a test machine to experiment on before committing to you main machine. I use this solution to use my EasyPIC4 programmer and to run Vladimir Soso's wonderful PIC Simulator IDE ([www.oshonsoft.com/pic.html](http://www.oshonsoft.com/pic.html)).

3. Dual boot – Certainly during an Ubuntu install, it will try to fit around already installed operating systems, and by default will still give you the option to boot a resident Windows install. By using the philosophy in solution 2, isolating this operating system from the world-wide web, you can use a minimal install and forgo AV, spyware, etc. You'd be amazed at how fast Windows runs when you put it on a diet.

Linux is not the whole solution (yet), but neither is Windows. In Windows you are reliant on all the paraphernalia required to give you some peace of mind that your PC has not been taken over, or that your whole system is going to die from a virus, and despite all the time and energy you spend protecting it, you still get a slight panic when you hear about the latest virus doing the rounds. Well I don't, not anymore.

Having said all this, there is another word on web browser security that is applicable to both Linux and Windows users. There is always a lot of talk about IE v Fire Fox, and I have used both extensively.

However, there is a third way, Opera ([www.opera.com](http://www.opera.com)). Opera has many unique features, but one that stands head and shoulders above the rest is that when you connect to a secure web page, Opera checks the level of security in use. If it feels that it is lacking, you get a pop up box telling you so, giving you the option of whether you wish to continue or not. My other favourite features of Opera are:

1. It is a combined browser and email client, meaning you only require one program running to do both functions, reducing the load on your PC yet more.

2. When you select a downloadable file from the Internet, in the background, while you are deciding if you wish to run it, or if/where you wish to save it, Opera has started the download. When you have finished deciding where you are going to put it, invariably the file has finished downloading and is ready to use. It is amazing how much time this feature saves.

Graham M Harby, via email

Alan (On-line Ed) replied to Graham:

Mr Harby makes some valid points that I don't disagree with. Many web servers run Linux and never miss a beat, including the *EPE Chat Zone* server at [www.chatzones.co.uk](http://www.chatzones.co.uk). Our problem is that rightly or wrongly Linux is not the operating system used in the mass market. My *Net Work* column is written for the mainstream Internet user, where Windows is ubiquitous (XP preferably), so in our context a feature on Linux is more appropriate for computer hobbyists and enthusiasts. I hope to install Linux on a spare PC when I get the time, once I've become familiar with Vista.

While it is hard to cover Linux, or Apple Mac OS, in our electronics magazine I don't dispute the cost benefits and superiority in some respects that Linux has, and the sheer elegance and usability that the Mac OS offers as well. In my view this is offset somewhat by the challenge Linux poses for software and hardware/driver choice, the need to be more of a 'computer enthusiast' and the reduced choice of peripherals and software available to Linux and MAC users (I sympathise).

## Shedding light on CFLs

Dear EPE,

Further to the correspondence about compact fluorescent lamps (CFLs) in previous issues, I've some new information to add. I've developed a means of photographing the luminous spectra emitted by light sources and you can see two examples here.

The photospectrograph of a conventional incandescent 100W GLS lamp is a broad smear of all the colours across the spectrum, from red (long wavelengths) to blue (short ones). Compare the comb of emissions from the compact fluorescent, with wide dark gaps between the spectral lines. No wonder they're hard to read by!

**Godfrey Manning G4GLM,**  
via email

*Most interesting Godfrey, thanks.  
Readers – any thoughts?*

## More on energy saving lamps

Dear EPE,

Just a quick response regarding the letter on page 71 of *Readout* in the March issue. Elemers' point is a fair one, but is covered in a document from Osram. In summary, the total energy, including manufacturing, transport, and energy during the use of one energy saving CFL for its entire life is quoted at 228.4kWh. The same calculation for ordinary GLS lamps over the same period is 1137.9kWh.

Extract from Osram's document:

'Whenever energy is used there is an impact on the environment. This impact principally takes the form of the release of carbon dioxide (CO<sub>2</sub>) when electricity is generated in fossil-fuelled power stations (1kWh of electricity = 1kg of CO<sub>2</sub> emissions).

'The CO<sub>2</sub> contributes significantly to the 'greenhouse effect', or global warming. Saving energy is therefore of utmost importance for environmental protection and for OSRAM. Compared with ordinary light bulbs, all OSRAM DULUX(r) EL LONGLIFE and ECONOMY lamps not only save energy during their lives, they need less energy for their manufacture.

'For an assumed efficiency of 37% (power station + power distribution), a molecular weight for CO<sub>2</sub> of 44 and a thermal value of 10kWh per 1kg of coal (carbon), 1kg CO<sub>2</sub> is produced per 1kWh of generated energy.

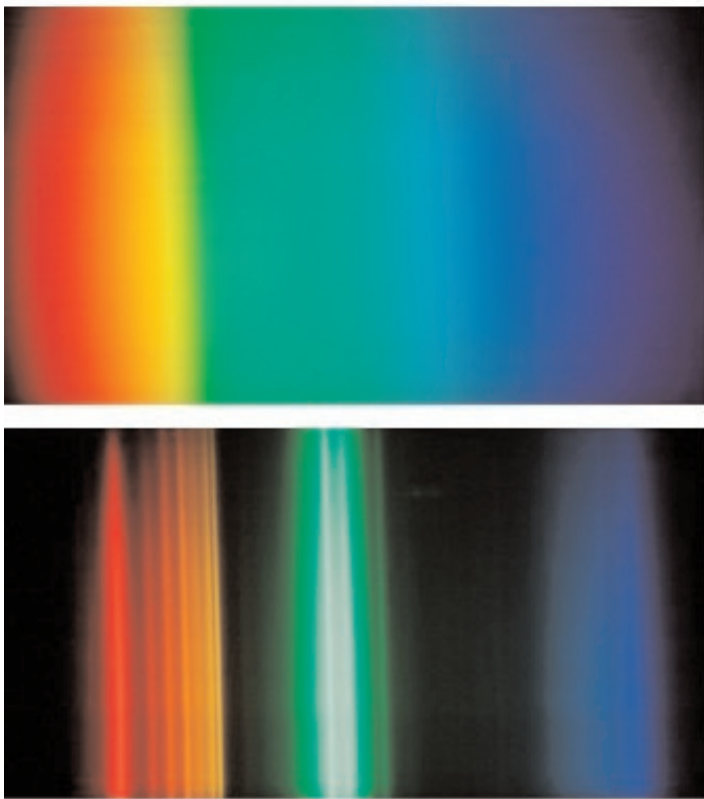
'What's more, mercury is released when energy is generated from fossil fuels, which means that in this respect the environmental impact of incandescent lamps is much greater than that of compact fluorescent lamps, even allowing for the mercury in the compact fluorescent lamp.

'All Osram Dulux EL Longlife and Economy lamps are environmentally friendly products because of their energy savings and the associated reduced environment impact (carbon dioxide and mercury).

Like all discharge lamps, they are enclosed systems in normal use. Apart from emitting light, they therefore can have no impact on the environment. A major substance in discharge lamps that is potentially harmful to the environment is mercury. Without it, however, the lamps would not work. Thanks to a patented dosing procedure, Osram has succeeded in reducing the mercury content to less than 3mg per lamp.'

**Dave Geary, via email**

*That's interesting reading Dave, many thanks*



## Hybrid electric cars

On the *Chat Zone* (via [www.epemag.co.uk](http://www.epemag.co.uk)) reader Edward Chase recently raised the topic of hybrid electric cars, resulting in quite a few responses. Here are some extracts:

**echase:** Ever considered getting a Toyota Prius? These hybrid electric/petrol cars are good fun for electrical/electronic enthusiasts like us because there are quite a few interesting modifications that can be done to them using PICs. See for example [www.hal.ne.jp/tamasu/](http://www.hal.ne.jp/tamasu/) and <http://priusdiy.fc2web.com/TACHO.html>. Translate the Japanese using Google translation or similar. There are many enthusiasts' forums covering them eg [http://autos.groups.yahoo.com/group/Mk1\\_Prius/](http://autos.groups.yahoo.com/group/Mk1_Prius/).

From a cost-effectiveness perspective, the price is low because most people are scared about buying old electronics, but many of you could easily fix them, so you don't have the same reasons the avoid them as others.

**zeitghost:** Too right, they're scared of buying old electronics – cost of replacement parts.

**grab:** I actually worked on the software for the *Ford Explorer* hybrid that's sold in the US. Same design as the Prius, because Toyota and Ford bought the technology from the same people.

One downside to older cars is battery life, as any laptop user will know. They're specified for 10 years, but NiMH batteries (which these use) do get progressively worse at holding a charge, so eventually you'll find it doing less and less electrically from a standing start. And a new battery pack is very pricey.

**echase:** Although some batteries have failed at medium mileages, average life is >100k and some have even done >200k. There are ways of changing individual cells as it's never a whole battery failure.

**Thomas:** How about the Indian Reva all-electric? There's someone in London

who drives one and blogs on the experience. Anyone have the address? *SC* magazine is running an article now on converting a Prius to >100mpg.

**hackinblack:** The French are well underway with a compressed-air powered car. It makes electrical cars seem rather outdated. It is being produced in India by TATA for the French syndicate MDI: <http://timesofindia.indiatimes.com/articleshow/2792877.cms>

**thomas:** Here's something on that Indian Reva all-electric car. Some links are here: [www.treehugger.com/files/2005/11/video-blog\\_reva.php](http://www.treehugger.com/files/2005/11/video-blog_reva.php).

**echase:** Grab, I am sure that there are some Prius owners who would like to tap your software knowledge to hack into their software. There are some pretty extreme hackers out there who do interesting things with their cars.

**kevinbrunt:** Is Trevor Bayliss working on the wind-up clockwork hybrid yet?

## HIDMaker FS

Dear EPE,

I read Robert Penfold's article on USB interfacing for electronics enthusiasts, but was surprised to find no mention of HIDMaker FS. I think that although it could be tidied by Trace Systems, it is the most useful USB facility that an amateur like myself could wish for, or any small manufacturing business.

It provides all the structure needed for both PC and microcontroller, and constructors working with USB should already have experience of programming of both of these. I'd previously bought modules designed to be added to gadgetry creating either a serial or parallel port, yet found them to be more complex than HIDMaker and will never use them again!

**Chris Gray, via email**

*Thanks Chris, your comments have been passed to Robert.*



# Net Work

Alan Winstanley



## Dual play

Previously, I summarised the main points to remember when sourcing a new broadband supplier. I offered some bouquets and brickbats for Tiscali, currently one of the most aggressive players in the broadband market. Local loop unbundling (LLU), which releases at least some of BT's grasp on the copper wires connected to your home, was first mentioned half a decade ago and some suppliers are now installing their own equipment into phone exchanges.

Tiscali is now openly gunning for what it calls 'dual play' services, combining Internet access and telephony, and then chasing the prospect of IPTV, television delivered via your broadband connection. BT offers BT Vision, an on-demand IP-delivered Freeview TV service. In fact, IPTV is nothing new, as residents in the city of Kingston-upon-Hull (on the skyline viewed from the writer's window) already know; Kingston Internet was far ahead of its time when, in a world first almost a decade ago, it began piping TV to local residents via its own DSL network, helped by the fact that it was Kingston Communications and not BT that owned the local network.

Ironically enough, the euphoria of having a dedicated local network delivering IPTV and video on demand then dimmed. The problem is that no outside ISP feels it is worth investing in the 'closed shop' of Hull, and some residents are now complaining bitterly about the effects of a monopolistic supplier and poor competition keeping prices artificially high. Sounds familiar?

As mentioned before, you get what you pay for – unless a monopoly controls the pricing. If price is paramount, then costs can be pared right down to the bone until you reach an 'everything is extra' tariff – which may include minimal or inept customer service. Regular *EPE* reader **Simon Faulkner** comments: 'There is really only one ISP for the technically minded in the UK – AAISP <http://aaisp.net.uk/>. They are reasonably small and have a hugely loyal customer base – the MD is on IRC most of the time and happy to talk to users like me!'

There was a dismissive reaction from another reader regarding the broadband list prices displayed by AAISP; there is no arguing that prices are clearly displayed, including a setup of £59.99 (\$120) and £46.99 (\$94) a month for 8MB broadband.

So what extra are you paying for? One answer is in Simon's recommendation about the unstinting dedication and personal service apparently shown by the owners of AAISP towards its customers (as used to be the case with Demon Internet in the early 1990s). The simple fact is that it is expensive to run any kind of business in the UK. Companies evolve to focus on high volumes of trade at lower margins, or run a much smaller business that – one hopes – provides a far better service at a proportionately higher price.

Only the customer can decide whether price or service is more important.

## BBC iPlayer

Thanks to the likes of gaming, streaming radio or TV, Internet usage is only ever going to increase, resulting in the eventual degradation of speed. Any supposed 'unlimited' broadband tariff includes a 'fair use' clause when the ISP decides what constitutes a reasonable level of usage before penalties are imposed.

Even this writer pleads 'guilty' to listening to *BBC Radio 2* in the daytime, delivered via broadband using the RealPlayer software. There is something benign about listening to an Internet radio station – as though it's not using much bandwidth, or it's operating in the background while you get on with the more serious job of surfing the web or buying something online.

After more than two years of trials, BBC Television launched iPlayer (see <http://www.bbc.co.uk/iplayer/>) at the end of 2007. The streaming TV service allows users to view in a Flash-enabled web browser many BBC TV programmes broadcast within the last seven days. The system analyses the visitor's IP address and restricts the service to UK-based users, due to copyright and licensing arrangements. The streaming system seems to be extremely simple to use and usually works commendably well. Basic parental controls are also available.

Some BBC TV programmes can also be downloaded as a Windows Media Video file for playing on a Windows XP or Vista PC. The download network partly relies on peer-to-peer sharing with other BBC iPlayer users, and the download features DRM (Digital Rights Management) services of Windows XP and Vista that will cause an 'unopened' programme to time out after typically 30 days, and once opened you may have up to seven days to view it as many times as you wish. Compatibility of DRM programmes with operating systems other than XP or Vista is promised later by the BBC. Note though, that the file sizes are huge – 400 to 600MB or so.

The BBC iPlayer is a masterpiece of usability that may well become an essential application for many broadband users. But of course – you need broadband to access it. The BBC is promoting its iPlayer very heavily, especially in the context of popular TV shows such as *Dr Who*. I hope to discuss more implications of the service next month. Britain's *Channel 4* offers 4OD (Four on Demand) for UK and ROI viewers – see [www.channel4.com/4od](http://www.channel4.com/4od). After installing a Windows program you can view the last 30 days' of *Channel 4* or pre-book your favourite episodes.

You can email your comments to me at: [alan@epemag.demon.co.uk](mailto:alan@epemag.demon.co.uk). I do enjoy your feedback and read every email, but unfortunately cannot always promise to correspond individually.



*The BBC iPlayer allows many BBC TV programmes from the previous seven days to be downloaded or streamed online to UK users. Some programmes are downloadable, but are 450 to 600MB in file size.*

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## Electronics Teach-In + Free CD-ROM

Mike Tooley

A broad-based introduction to electronics – find out how circuits work and what goes on inside them. Plus 15 easy-to-build projects. The 152 page A4 book comes with a free CD-ROM containing the whole Teach-In 2006 series (originally published in *EPE*) in PDF form, interactive quizzes to test your knowledge, TINA circuit simulation software (a limited version – plus a specially written TINA Tutorial), together with simulations of the circuits in the Teach-In series, plus Flowcode (a limited version) a high level programming system for PIC microcontrollers based on flowcharts.

The Teach-In series covers everything from Electric Current through to Microprocessors and Microcontrollers and each part includes demonstration circuits to build on breadboards or to simulate on your PC.

In addition to the Teach-In series, the book includes 15 CMOS-based simple projects from the *Back-To-Basics* series by Bart Trepak, these are: Fridge/Freezer Alarm, Water Level Detector, Burglar Alarm, Scarecrow, Digital Lock, Doorchime, Electronic Dice, Kitchen Timer, Room Thermometer, Daily Reminder, Whistle Switch, Parking Radar, Telephone Switch, Noughts and Crosses Enigma and a Weather Vane. There is also a MW/LW Radio project in the Teach-In series.

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Details building and programming instructions provided, including numerous step-by-step photographs.

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### MORE ADVANCED ROBOTICS WITH LEGO MINDSTORMS – Robert Penfold

Covers the Vision Command System

Shows the reader how to extend the capabilities of the brilliant Lego Mindstorms Robotic Invention System (RIS) by using Lego's own accessories and some simple home constructed units. You will be able to build robots that can provide you with 'waiter service' when you clap your hands, perform tricks, 'see' and avoid objects by using 'bats radar', or accurately follow a line marked on the floor. Learn to use additional types of sensors including rotation, light, temperature, sound and ultrasonic and also explore the possibilities provided by using an additional (third) motor. For the less experienced, RCX code programs accompany most of the featured robots. However, the more adventurous reader is also shown how to write programs using Microsoft's VisualBASIC running with the ActiveX control (Spirit.OCX) that is provided with the RIS kit.

Detailed building instructions are provided for the featured robots, including numerous step-by-step photographs. The designs include rover vehicles, a virtual pet, a robot arm, an 'intelligent' sweet dispenser and a colour conscious robot that will try to grab objects of a specific colour.

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For a further selection of books see the next two issues of *EPE*.

## Radio

### BASIC RADIO PRINCIPLES AND TECHNOLOGY

Ian Poole

Radio technology is becoming increasingly important in today's high technology society. There are the traditional uses of radio which include broadcasting and point to point radio as well as the new technologies of satellites and cellular phones. All of these developments mean there is a growing need for radio engineers at all levels.

Assuming a basic knowledge of electronics, this book provides an easy to understand grounding in the topic.

Chapters in the book: Radio Today, Yesterday, and Tomorrow; Radio Waves and Propagation; Capacitors, Inductors, and Filters; Modulation; Receivers; Transmitters; Antenna Systems; Broadcasting; Satellites; Personal Communications; Appendix – Basic Calculations.

263 pages Order code NE30 £20.00

### PROJECTS FOR RADIO AMATEURS AND S.W.L.S.

R. A. Penfold

This book describes a number of electronic circuits, most of which are quite simple, which can be used to enhance the performance of most short wave radio systems.

The circuits covered include: An aerial tuning unit; A simple active aerial; An add-on b.f.o. for portable sets;

A wavetrap to combat signals on spurious responses; An audio notch filter; A parametric equaliser; C.W. and S.S.B. audio filters; Simple noise limiters; A speech processor; A volume expander.

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92 pages Order code BP304 £4.45

### AN INTRODUCTION TO AMATEUR RADIO

I. D. Poole

Amateur radio is a unique and fascinating hobby which has attracted thousands of people since it began at the turn of the century. This book gives the newcomer a comprehensive and easy to understand guide through the subject so that the reader can gain the most from the hobby. It then remains an essential reference volume to be used time and again. Topics covered include the basic aspects of the hobby, such as operating procedures, jargon and setting up a station. Technical topics covered include propagation, receivers, transmitters and aerials etc.

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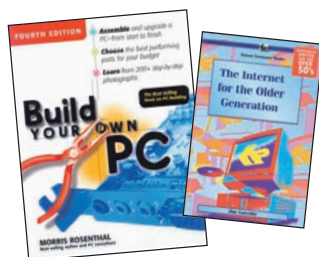
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This book explains how to use your PC on the Internet and covers amongst other things: Choosing and setting up your computer for the Internet. Getting connected to the Internet. Sending and receiving emails, photographs, etc., so that you can keep in touch with family and friends all over the world. Searching for and saving information on any subject. On-line shopping and home banking. Setting up your own simple web site.

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### BUILD YOUR OWN PC – Fourth Edition

Morris Rosenthal

More and more people are building their own PCs. They get more value for their money, they create exactly the machine they want, and the work is highly satisfying and actually fun. That is, if they have a unique beginner's guide like this one, which visually demonstrates how to construct a state-of-the-art computer from start to finish.

Through 150 crisp photographs and clear but minimal text, readers will confidently absorb the concepts of computer building. The extra-big format makes it easy to see what's going on in the pictures. The author goes 'under the hood' and shows step-by-step how to create a Pentium 4 computer or an Athlon 64 or Athlon 64FX, covering: What first-time builders need to know; How to select and purchase parts; How to assemble the PC; How to install Windows XP. The few existing books on this subject, although outdated, are in steady demand. This one delivers the expertise and new technology that fledgling computer builders are eagerly looking for.

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### THE PIC MICROCONTROLLER YOUR PERSONAL INTRODUCTORY COURSE – THIRD EDITION

John Morton

Discover the potential of the PIC microcontroller through graded projects – this book could revolutionise your electronics construction work!

A uniquely concise and practical guide to getting up and running with the PIC Microcontroller. The PIC is one of the most popular of the microcontrollers that are transforming electronic project work and product design.

Assuming no prior knowledge of microcontrollers and introducing the PICs capabilities through simple projects, this book is ideal for use in schools and colleges. It is the ideal introduction for students, teachers, technicians and electronics enthusiasts. The step-by-step explanations make it ideal for self-study too: this is not a reference book – you start work with the PIC straight away.

The revised third edition covers the popular reprogrammable Flash PICs: 16F54/16F84 as well as the 12F508 and 12F675.

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### PROGRAMMING 16-BIT PIC MICROCONTROLLERS IN C

– Learning to Fly the PIC24 Lucio Di Jasio (Application Segments Manager, Microchip, USA)

A Microchip insider tells all on the newest, most powerful PICs ever! Focuses on examples and exercises that show how to solve common, real-world design problems quickly. Includes handy checklists to help readers perform the most common programming and debugging tasks. FREE CD-ROM includes source code in C, the Microchip C30 compiler, and MPLAB SIM software, so that readers gain practical, hands-on programming experience.

Until recently, PICs didn't have the speed and memory necessary for use in designs such as video- and audio-enabled devices. All that has changed with the introduction of the first-ever 16-bit PIC family, the PIC24. This new guide teaches readers everything they need to know about the architecture of these new chips, how to program them, how to test them and how to debug them. Lucio's common-sense, practical, hands-on approach starts out with basic functions and guides the reader step-by-step through even the most sophisticated programming scenarios.

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Owen Bishop

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The book also presents a dozen filter-based projects with applications in and around the home or in the constructor's workshop. These include a number of audio projects such as a rhythm sequencer and a multi-voiced electronic organ.

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88 pages

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Ian R. Sinclair

This book, intended for enthusiasts, students and technicians, seeks to establish a firm foundation in digital electronics by treating the topics of gates and flip-flops thoroughly and from the beginning.

Topics such as Boolean algebra and Karnaugh mapping are explained, demonstrated and used extensively, and more attention is paid to the subject of synchronous counters than to the simple but less important ripple counters. No background other than a basic knowledge of electronics is assumed, and the more theoretical topics are explained from the beginning, as also are many working practices. The book concludes with an explanation of microprocessor techniques as applied to digital logic.

200 pages

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Mike James

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240 pages

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## Project Building & Testing

### ELECTRONIC PROJECT BUILDING

FOR BEGINNERS

R. A. Penfold

This book is for complete beginners to electronic project building. It provides a complete introduction to the practical side of this fascinating hobby, including the following topics:

Component identification, and buying the right parts; resistor colour codes, capacitor value markings, etc; advice on buying the right tools for the job; soldering; making easy work of the hard wiring; construction methods, including stripboard, custom printed circuit boards, plain matrix boards, surface mount boards and wire-wrapping; finishing off, and adding panel labels; getting "problem" projects to work, including simple methods of fault-finding.

In fact everything you need to know in order to get started in this absorbing and creative hobby.

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### ELECTRONIC PROJECTS FOR EXPERIMENTERS

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The subjects covered include:- Magnetic field detector, Basic Hall effect compass, Hall effect audio isolator, Voice scrambler/descrambler, Bat detector, Bat style echo location, Noise cancelling, LED stroboscope, Infra-red "torch", Electronic breeze detector, Class D power amplifier, Strain gauge amplifier, Super hearing aid.

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The projects include:- Simple audio links, F.M. audio link, P.W.M. audio links, Simple d.c. links, P.W.M. d.c. link, P.W.M. motor speed control, RS232C data links, MIDI link, Loop alarms, R.P.M. meter.

All the components used in these designs are readily available, none of them require the constructor to take out a second mortgage.

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W.D. Phillips

A good introduction to PIC

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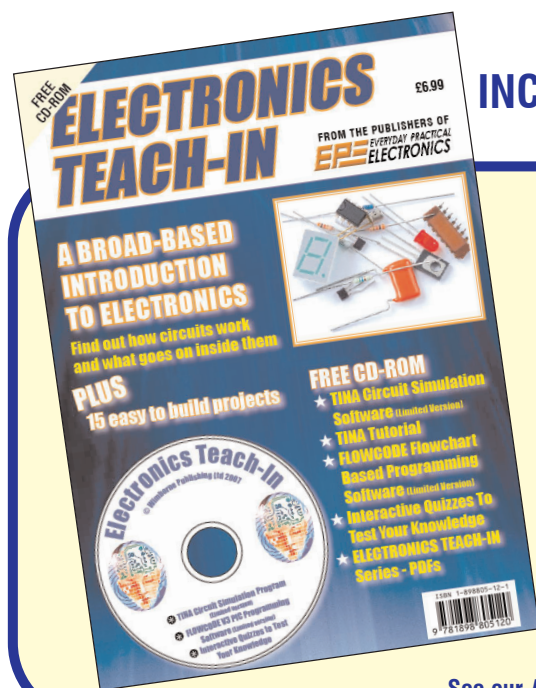
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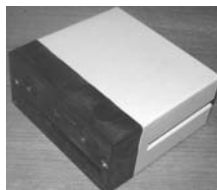
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**JULY '08 ISSUE ON SALE JUNE 12**

## ADVERTISERS INDEX

AUDON ELECTRONICS .....	67
BETA-LAYOUT .....	67
COMPACT CONTROL DESIGN .....	21
DISPLAY ELECTRONICS .....	72
ESR ELECTRONIC COMPONENTS .....	.6, Cover (iii)
JAYCAR ELECTRONICS .....	4/5
JPG ELECTRONICS .....	72
LABCENTER .....	Cover (iv)
LASER BUSINESS SYSTEMS .....	47
MAGENTA ELECTRONICS .....	67
MICROCHIP .....	Cover (ii)
NURVE NETWORKS LLC .....	27
PALTRONIX .....	21
PEAK ELECTRONIC DESIGN .....	55
PICO TECHNOLOGY .....	19
QUASAR ELECTRONICS .....	2/3
SHERWOOD ELECTRONICS .....	67
STEWART OF READING .....	55

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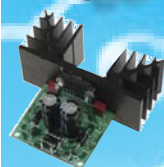
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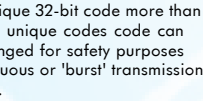
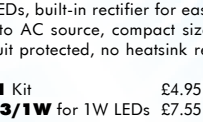
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For use with the K8057/VM109 2-channel RF receivers.

Generates unique 32-bit code more than 1,000,000,000 unique codes code can easily be changed for safety purposes choose continuous or 'burst' transmission LED indicator.

**K8059** Kit £8.95



### Remote Control Receiver

Two relay contact outputs for use with K8059 and VM108 two channel RF code lock transmitters, toggle or pulse function selectable per output, can learn a unique 32-bit code from the transmitters, store up to 31 transmitters, LED indicators for outputs and functions.

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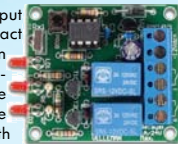
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